UNIVERSITY OF BRISTOL

THE ANNUAL REPORT

OF THE

Agricultural and Horticultural Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL

1959

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Secretary.

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LIST OF STAFF—1959.

Long Ashton Research Station.

Director :
PROFESSOR H. G. H. KEARNS, O.B.E., B.Sc. (Lond.), Ph.D., Dip. Agric. (Cantab.).

Assistant Directors :
R. W. MARSH, M.A. (Cantab.).
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Secretary :
A. L. LEGGETT, F.C.A.

Nutrition of Fruit Plants :
C. BOULD, M.Sc., Ph.D. (Reading).
*R. A. WEBB, B.A., D.Phil. (Oxon.).
D. G. HILL-COTTINGHAM, M.Sc. (Lond.), Ph.D. (Bristol), A.R.I.C.
E. G. BRADFIELD, A.R.I.C.
*D. G. HALLAS.
G. V. C. DAVIES, B.Sc. (Bristol). (*Resigned* 15 *December*, 1959).
W. K. HANCOCK.
P. BALE.
MISS S. A. JOHNSON.

Pomology and Plant Breeding :
L. C. LUCKWILL, B.Sc., Ph.D. (Bristol).
D. L. ABBOTT, B.Sc. (Lond.).
R. R. WILLIAMS, B.Sc., Dip. Hort. Sci. (Bristol).
D. WILSON, B.Sc. (Dunelm), Ph.D. (Wales). (Plant Breeder).
MISS B. A. RAKE, B.Sc. (Reading), N.D.H.
A. I. CAMPBELL, N.D.H. (Hons.).
P. S. WEAVER.
MISS G. NORTH-SMITH.
MISS A. TURNER.
R. D. CHILD.
MISS M. W. SHELLARD.

Organic Chemistry :
D. WOODCOCK, D.Sc., Ph.D. (Dunelm), F.R.I.C.
MISS M. RANDALL, B.Sc. (St. Andrews). (*Appointed* 5 *January*, 1959).
D. R. CLIFFORD.
J. K. FAULKNER, B.Sc. (Lond.), Grad.R.I.C. (*Transferred from A.R.C. Unit* 1 *July*, 1959).
B. L. DAVIES, Grad.R.I.C. (*On National Service from* 14 *June*, 1959).
R. H. DAVIS.

Physical Chemistry :
W. D. E. THOMAS, B.Sc., Ph.D. (Wales), F.R.I.C.
C. P. LLOYD-JONES, B.Sc. (Bristol), A.R.I.C. (Radioisotopes).
L. POTTER.
MISS M. R. MANNING.
MISS J. PARSONS.

Analytical and General Chemistry :
J. T. MARTIN, B.Sc. (Birm.), D.Sc., Ph.D. (Lond.), F.R.I.C.
E. SOMERS, M.Sc. (Leeds), Ph.D. (Bristol).
E. J. SKERRETT, Ph.D. (Bristol), A.R.I.C.
D. V. RICHMOND, B.Sc. (Lond.), Dip. Hort. Sci. (Bristol), A.R.I.C.
MISS M. F. ROBERTS, B.A. (North Staffs.), M.Sc. (Bristol). (*Appointed* 1 *November*, 1959).
R. F. BATT.
J. A. PICKARD.
E. A. BAKER.
*G. J. DICKES.
R. J. PRING.

* Transferred from A.R.C. Unit 1 October, 1959.

LIST OF STAFF—*continued.*

Plant Biochemistry :

*H. E. Davenport, B.Sc. (Lond.), Ph.D. (Cantab.).
*Miss J. M. Bradford.

Plant Physiology :

E. J. Hewitt, B.Sc. (Lond.), Ph.D. (Bristol), A.K.C.
*A. J. Abbott, M.Sc., Dip. Hort. (Reading).
*B. A. Notton, A.R.I.C.
*D. P. Hucklesby, B.Sc. (Lond.).
*Miss K. A. Taylor, B.Sc. (Lond.).
*D. M. James.
*E. F. Watson.

Chemical Microbiology :

D. J. D. Nicholas, D.Sc. (Lond.), Ph.D. (Bristol), A.K.C., F.R.I.C. (*Seconded by A.R.C.*).
O. T. G. Jones, B.Sc., Ph.D. (Liverpool). (*Resigned* 16 *October*, 1959).
J. H. Anderson, B.Sc., Ph.D. (Aberdeen). (*Appointed* 19 *October*, 1959).
W. J. Redmond. (*Seconded by A.R.C.*).
*D. J. Fisher.
*M. A. Wright.
*Miss M. Poulson.
P. J. Wilson. (*Appointed* 12 *October*, 1959).

Plant Constituents :

*A. H. Williams, B.Sc., M.A. (Oxon.).
*J. M. Jarrett.
*J. S. Challice.

Entomology :

H. G. H. Kearns, O.B.E., B.Sc. (Lond.), Ph.D., Dip. Agric., (Cantab.).
S. H. Bennett, B.Sc., Ph.D. (Bristol).
N. G. Morgan, B.Sc., Ph.D. (Bristol).
A. Stringer, B.Sc. (Lond.), A.R.C.S.
C. G. L. Furmidge, B.Sc., Ph.D. (Nottingham), A.R.I.C. (Physical Chemistry).
H. R. Mapother, B.A., B.Sc. (Dublin).
T. E. Cobbald, B.Sc. (Lond.), G.I.Mech.E.
B. D. Smith, B.Sc. (Sheffield), Ph.D. (Lond.), D.I.C. (*A.R.C. Special Grant*).
A. H. Wilkins.
Miss M. P. Scadding. (*Leave of absence from* 9 *September*, 1959).
J. H. Russell.
Miss A. R. Tapscott.
Miss B. K. I. Bird.
Miss D. I. Conibear.
Miss P. J. Herrington.
A. A. Baker.
Miss G. J. Browning. (*Appointed* 1 *October*, 1959).

Plant Pathology :

R. W. Marsh, M.A. (Cantab.).
R. J. W. Byrde, B.Sc. (Hort.), Ph.D. (Reading).
A. T. K. Corke, B.Sc., Ph.D. (Edin.).
A. H. Fielding.
Miss N. M. Waugh. (*Resigned* 4 *August*, 1959).
Miss M. Marlow. (*Resigned* 23 *May*, 1959).
Miss M. Waller. (*Resigned* 15 *May*, 1959).
Miss M. A. Mealing. (*Appointed* 6 *July*, 1959).
Miss R. P. Beer. (*Appointed* 17 *August*, 1959).
V. W. L. Jordan. (*Appointed* 1 *September*, 1959).

Cider and Fruit Juices :

A. Pollard, M.Sc. (Lond.), Ph.D. (Manc.).
G. C. Whiting, B.Sc., Ph.D. (Sheffield). (Chemistry).
L. F. Burroughs, B.Sc. (Reading), Ph.D. (Bristol), A.R.I.C. (Chemistry).
F. W. Beech, B.Sc. (Birm.), Ph.D. (Bristol), A.R.I.C. (Microbiology).
Miss M. E. Kieser, B.Sc. (Bristol), A.R.I.C. (Chemistry).

* Transferred from A.R.C. Unit 1 October, 1959.

LIST OF STAFF—*continued.*

Cider and Fruit Juices: —*contd.*	C. F. Timberlake, M.Sc. (Wales), Ph.D. (Bristol), A.R.I.C. (Chemistry).
	J. G. Carr, B.Sc., Ph.D. (Bristol). (Microbiology.)
	R. J. Hathway. (Cider-Maker).
	J. H. H. Llewellyn.
	R. A. Coggins.
	D. J. Sissons.
	A. H. Sparks.
	Miss J. J. Bird.
	Miss V. L. Fowler.
	Miss S. M. Benson.
	R. R. Davenport.
	Mrs. G. M. Hunt (née Badman).
	Miss P. M. Stevens.
Domestic Food Preservation:	Miss B. A. Crang, B.Sc. (Lond.).
	Miss M. Leach, N.D.P.
	Miss G. M. Fawkes, B.Sc. (Bristol). (*Resigned* 3 *August*, 1959).
	Miss M. J. Davey, B.Sc. (Bristol). (*Appointed* 1 *October*, 1959).
	Miss E. M. Filer.
	Miss P. J. Davey.
	*Miss M. Franklin.
Willows:	K. G. Stott, B.Sc. (Wales).
	T. W. Cox.
Statistics:	G. M. Clarke, M.A., Dip. Stat. (Oxon.).
	Miss M. E. Holgate, M.A. (Oxon.).
	Miss A. J. Knight.
	Miss S. J. Sage. (*Resigned* 12 *September*, 1959).
	Miss D. Greenhow. (*Appointed* 14 *September*, 1959).
Scientific Liaison:	M. Greenwood, O.B.E., M.Sc. (Manc.). (Scientific Liaison Officer).
	G. E. Clothier. (Station Guide and Meteorological Recorder).
Library:	P. R. Colegate. (Librarian).
	Miss D. A. Pearce.
Laboratory Staff:	G. H. Jones, A.R.P.S. (Chief Laboratory Steward).
	E. R. Wilkins.
	E. W. Spear.
	R. W. Coates.
	R. A. Green. (*Resigned* 25 *September*, 1959).
	A. Mountjoy. (*Appointed* 12 *October*, 1959).
	G. Kitchingham.
Plantations and Greenhouses:	E. W. Hobbis, M.B.E., B.Sc. (Bristol), N.D.H. (Plantations Officer).
	S. H. Legge. (Marketing Officer and Recorder).
	E. Catlow. (Recorder).
	C. S. Gundry, S.D.H. (Greenhouse Officer).
	R. M. Jarrett. (Recorder).
	C. W. Harper. (Spraying Recorder).
	N. T. Weatheritt, N.D.H. (Recorder). (*Resigned* 31 *August*, 1959).
	J. S. Coles, N.D.H. (Propagator and Recorder).
	D. O. Berks. (Recorder). (*Appointed* 14 *September*, 1959).
	A. J. Hurdle. (Plantations Foreman).
	J. G. Clarke. (Greenhouse Foreman).
Workshops and Maintenance:	S. E. Cole.
	H. J. Jones.
	E. A. Fribbins.
	B. F. Shearn.
	K. G. Jones.
	R. S. Cole.
	J. G. Hurley.

* Transferred from A.R.C. Unit 1 October, 1959.

LIST OF STAFF—*continued.*

Refectory :

Miss P. S. Batcheller. (*Appointed* 1 *October*, 1959).
Mrs. N. M. King.
Mrs. E. R. Duddridge.

Administrative and Clerical Staff :

R. A. Merchant. (Chief Clerk, Accounts).
D. H. Pittman. (Cashier).
Miss M. H. Simpson. (Director's Secretary).
J. Packer. (Senior Clerk).
T. J. Ford.
Mrs. M. Wippell.
Miss J. M. Walters.
Miss P. Curtis.
Miss C. F. Hales.
Mrs. V. P. L. Ford (née White).
Miss C. G. Barnett. (*Resigned* 30 *June*, 1959).
Miss P. Crocome. (*Appointed* 1 *August*, 1959).
Miss G. M. Rew. (*Resigned* 30 *September*, 1959).
Miss P. M. Heyward. (*Resigned* 19 *September*, 1959).
Miss E. M. Lawrence.
Miss P. R. Hale. (*Appointed* 21 *September*, 1959).
Miss P. A. Weeks. (*Appointed* 1 *October*, 1959).

Outdoor and Cider House Staff with more than 20 years' service :

J. C. W. Barnes (31).
W. M. Hynam (31).
F. W. Hynam (30).
K. J. Escott (29).

Agricultural Research Council Unit of Plant Nutrition (Micro-Nutrients).

(Disbanded 30th September, 1959)

Honorary Director :
Professor T. Wallace, C.B.E., M.C., D.Sc., F.R.I.C., V.M.H., F.R.S.

H. E. Davenport, B.Sc. (Lond.), Ph.D. (Cantab.).
E. J. Hewitt, B.Sc. (Lond.), Ph.D. (Bristol), A.K.C. (*Seconded to Unit*).
D. J. D. Nicholas, D.Sc. (Lond.), Ph.D. (Bristol), A.K.C., F.R.I.C.
R. A. Webb, B.A., D.Phil. (Oxon.).
A. H. Williams, B.Sc., M.A. (Oxon.).
H. M. Stevens, B.Sc., Ph.D. (Bristol). (*Resigned* 30 *September*, 1959).
A. J. Abbott, M.Sc., Dip. Hort. (Reading).
O. T. G. Jones, B.Sc., Ph.D. (Liverpool).
W. J. Redmond.
D. J. Fisher.
B. A. Notton, A.R.I.C.
D. G. Hallas.
J. Jarrett.
D. P. Hucklesby, B.Sc. (Lond.).
M. A. Wright.
J. S. Challice.
G. L. Mabey. (*Resigned* 30 *September*, 1959).
G. J. Dickes.
J. K. Faulkner, B.Sc. (Lond.). Grad. R.I.C. (*Transferred to Organic Chemistry* 1 *July*, 1959).
M. W. J. Heyes. (*Resigned* 31 *March*, 1959).
D. M. James.
Miss K. A. Taylor.
Miss J. M. Bradford.
Miss M. Franklin.
Miss M. Poulson.
E. F. Watson.

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INTRODUCTION.

By H. G. H. KEARNS, Director.

Substantial progress was made in 1959 in implementing the comprehensive scheme for building developments first announced in the 1950 Annual Report. The Refectory–Common Room was equipped and brought into use at the end of the year, while the main constructional work was completed on the two-storied laboratory and office block, to be known as the Wallace Laboratory in recognition of Professor Wallace's services to the Station. These developments have necessarily made inroads into the original cider orchard which stands as one of the remaining links with the Station's foundation in 1903 ; but much of the orchard will be preserved as an amenity of historic interest.

In November, Captain D. M. Wills, Chairman of the Agricultural Committee, underwent an operation from which he made a speedy recovery. It is also gratifying to record the complete restoration to health of Professor Wallace and Mr. Leggett. Professor Wallace's future connexion with the Station has been strengthened by his appointment to the Agricultural Committee as a representative of the National Fruit and Cider Institute. The vacancy on this Committee left by the death of Professor Maskell has been filled by the nomination of Professor W. T. Williams, holder of the Chair of Botany in the University of Southampton, as the representative of the Agricultural Research Council ; the other A.R.C. representative, Mr. G. Samuel, who had been a valued member of the Committee since 1956, resigned at the end of 1959 and has not been replaced.

A former member of the Finance and Business Sub-Committee, Mr. H. E. Keeler, died on 31st December. Mr. Keeler was first associated with the Station in 1912 in his capacity as University Auditor, and, since his retirement, served on the Sub-Committee until 1956.

On 30th September Professor Wallace retired from the Honorary Directorship of the A.R.C. Unit of Plant Nutrition (Micro-nutrients). He contributes an account of the formation and development of the Unit on page 46. As a consequence of the recommendations of the A.R.C. Visiting Group in 1958, the Unit was disbanded with effect from 30th September, on the termination of Professor Wallace's Honorary Directorship. The staff was transferred to the Station, excepting Dr. Nicholas and Mr. Redmond—who were seconded to Long Ashton while remaining on the strength of the A.R.C.—and Dr. O. T. G. Jones and Dr. H. M. Stevens, who had obtained other appointments. The titles of the Unit sub-sections transferred to the Station, with their respective heads, are : Plant Physiology (Dr. Hewitt) ; Chemical Microbiology (Dr. Nicholas) ; Plant Biochemistry (Dr. Davenport) ; Plant Constituents (Mr. Williams).

A further recommendation of the A.R.C. was that, in view of the additional duties devolving on the Director as a result of this increase of staff and of the extension of the Station buildings, two Assistant Directors should be appointed. Mr. Marsh and Dr. Martin were appointed to fill these positions from 5th February.

Dr. Martin was elected in July to a University of Bristol Readership in the Chemistry of Insecticides and Fungicides. Dr. Martin came to Long

Ashton in 1951 with an established reputation, gained at Rothamsted and in the Ministry's Plant Pathology Laboratory at Harpenden, as an authority on chemical means of pest and disease control. He played a leading part in the inception of the Ministry's approval scheme for proprietary crop protection materials, and as a member of the inter-departmental committees dealing with hazards arising from the use of toxic chemicals in agriculture. Since his appointment as Head of the Chemistry Section at Long Ashton the work of the Section has rapidly extended, particularly in analytical studies of spray deposition and spray residues.

The co-operative activities of the Station have continued in a wide variety of fields, both at home and overseas. Professor Wallace remains the United Kingdom representative in the United Nations Food and Agriculture Organization project for international research on trace elements : during Professor Wallace's illness Dr. Hewitt deputized for him at the F.A.O. conference in Dublin in March. The Trace-Element Committee set up by the A.R.C. appointed Dr. Bould as one of their members with effect from February 1959. The Plant Phenolics Group held a meeting in Bristol on 2nd–3rd April, to which papers were contributed by members of the Long Ashton staff.

Among the instances of co-operation with the N.A.A.S. were the discussions at Long Ashton with agricultural and horticultural advisory officers on the subjects of cider orcharding and willow-growing. A spraying course for Safety and Wages Inspectorate was held on 10th July. The annual Refresher Course for officers of the National Agricultural Advisory Service was held at Long Ashton on 8th and 9th July and attended by 45 officers of the N.A.A.S. and 12 officers of Local Education Authorities.

Help was given to the Royal Botanic Gardens, Kew, in the provision of specifications and equipment for an artificial rain system in the Palm House. A further link with the National Vegetable Research Station was formed by the visit of Dr. Keyworth, who spoke at a Staff Meeting on " Some aspects of plant pathology research at Wellesbourne." The Bath and West Society co-opted the Director on to their Experiments and Education Committee and the Bristol College of Technology, in setting up their Applied Sciences Advisory Committee, appointed Mr. Marsh as the Long Ashton representative. Mr. Hobbis arranged, with the co-operation of the N.A.A.S., for a party of the Plantations Section to visit fruit farms in Oxfordshire and Berkshire on 4th and 5th June. The Station is greatly indebted to the owners of the orchards and to the N.A.A.S. for making the tour so successful.

Overseas contacts include the appointment of Dr. Hewitt as adviser on nutritional work to the West African Institute for Oil Palm Research, Benin City, Nigeria. Investigations made for the Colonial Office under the scheme arranged by the A.R.C. have included studies on coconut pests and diseases in the Solomon Islands and in East Africa ; on a virus disease of Manila hemp (*Musa textilis*) in North Borneo ; on leaf spot of bananas in Jamaica ; and on a mercury residue problem on coffee berries in Kenya. Spraying machines have been made for hemp in North Borneo and for horticultural crops in Kenya and St. Helena. Experience since the scheme first operated in 1955 has shown that problems can be solved more speedily if the specialist first visits the overseas territory for field investigations, then returns to work on the subject with the aid of the facilities available at Long Ashton.

Staff.

The academic status of ten members of staff was raised in October from Research Assistant to Lecturer. It was agreed that no further promotions or appointments " with the standing of Lecturer in the University " should be made at Long Ashton, but that the more appropriate status of Research Fellow should be open to members of Long Ashton staff. Promotion to this status from Research Assistant or Lecturer, and direct appointments with this status, will be made on grounds of outstanding merit.

In further discussions with the University Science Board the requirements of Long Ashton candidates for higher degrees in the University were clarified.

Appointments to Scientific Staff.

Miss Margaret Randall, B.Sc., was appointed on 5th January as Scientific Officer in the Organic Chemistry Section, to succeed Dr. Downing. Miss Randall graduated in 1957 from St. Andrews University and subsequently held an appointment at the Worcester Foundation for Experimental Biology, Shrewsbury, Massachusetts, U.S.A.

Dr. J. H. Anderson, B.Sc., Ph.D., was appointed from 19th October in the Chemical Microbiology Section, in succession to Dr. O. T. G. Jones. Dr. Anderson is a graduate of Aberdeen University : from 1956 to 1959 he was an A.R.C. postgraduate student there in the Department of Biological Chemistry under the direction of Dr. Howard Lees and Professor W. O. Kermack, F.R.S., and was awarded the Ph.D. degree for his thesis on " Studies in the biochemistry of ammonia oxidation by the autotrophic nitrifying organism, *Nitrosomonas* ".

Miss Margaret Roberts, M.Sc., a former Boots' Scholar, was appointed from 1st November to a new post in the Analytical Chemistry Section under the direction of Dr. Martin.

Miss Patricia Batcheller became the first Domestic Supervisor at the Station from 1st October, 1959, with responsibility for the catering in the Refectory and for the supervision of all domestic staff. Miss Batcheller has had extensive experience of catering management in schools in England and at the East African Agriculture and Forestry Research Organisation, Kenya.

Appointments to Assistant Staff :

Miss M. J. Davey, B.Sc., Assistant Experimental Officer (for bacteriology), Domestic Food Preservation Section, from 1st October.

Mrs. E. Sims, B.Sc., Temporary Assistant Experimental Officer, Domestic Food Preservation Section, from 10th August.

Miss M. A. Mealing, Assistant (Scientific), Plant Pathology Section, from 6th July.

Miss R. P. Beer, Assistant (Scientific), Plant Pathology Section, from 17th August.

Mr. V. W. L. Jordan, Assistant (Scientific), Plant Pathology Section, from 1st September.

Miss D. Greenhow, Assistant (Scientific), Statistics Section, from 14th September.

Miss G. J. Browning, Assistant (Scientific), Entomology Section, from 1st October.

Mr. D. Berks, Assistant (Scientific), Plantations, from 14th September.

Mr. P. J. Wilson, Assistant (Scientific), Chemical Microbiology, from 12th October.

Mr. A. Mountjoy, Laboratory Attendant, from 12th October.

Appointments to Administrative Staff:

Miss P. Crocome, Shorthand Typist, Grade I, from 1st August.

Miss P. A. Weeks, Clerical Staff, from 1st October.

Miss P. R. Hale, Junior Clerk, from 21st September.

Resignations from Scientific Staff:

Dr. H. M. Stevens, B.Sc., Ph.D., Senior Scientific Officer, Unit of Plant Nutrition, from 30th September.

Dr. O. T. G. Jones, B.Sc., Ph.D., Scientific Officer, Chemical Microbiology, from 16th October.

Dr. H. Murray Stevens was appointed as Inorganic Chemist in the A.R.C. Unit of Plant Nutrition on 1st January, 1954. During his work at Long Ashton he made valuable contributions to the study of the valency states of metallic elements, particularly iron, molybdenum, vanadium and cobalt.

Dr. O. T. G. Jones joined Dr. Nicholas in the A.R.C. Unit on 26th November, 1956, and worked principally on nitrogen and sulphur metabolism in bacteria and fungi.

Resignations from Assistant Staff:

Miss G. M. Fawkes, B.Sc., Assistant Experimental Officer, Domestic Food Preservation Section, from 3rd August.

Mr. G. V. C. Davies, B.Sc., Assistant Experimental Officer, Nutrition of Fruit Plants Section, from 15th December.

Mrs. E. Sims, B.Sc., Temporary Experimental Officer, Domestic Food Preservation Section, from 30th September.

Miss N. M. Waugh, Assistant Experimental Officer, Plant Pathology Section, from 4th August.

Mr. N. T. Weatheritt, Assistant Experimental Officer, Plantations Section, from 31st August.

Mr. G. L. Mabey, Assistant Experimental Officer, Unit of Plant Nutrition, from 30th September.

Mr. M. W. J. Heyes, Assistant (Scientific), Unit of Plant Nutrition, from 31st March.

Miss M. Waller, Assistant (Scientific), Plant Pathology Section, from 15th May.

Miss M. Marlow, Assistant (Scientific), Plant Pathology Section, from 23rd May.

Miss S. J. Sage, Assistant (Scientific), Statistics, from 12th September.

R. A. Green, Laboratory Attendant, from 26th September.

Resignations from Administrative Staff:

Miss C. G. Barnett, Shorthand Typist, from 30th June.

Miss P. M. Heyward, Clerical Staff, from 19th September.

Miss G. M. Rew, Clerical Staff, from 30th September.

National Service :

Mr. B. L. Davies, Grad. A.R.I.C., Assistant Experimental Officer, Organic Chemistry Section, was called up for National Service from 14th June.

Return from Sandwich Course :

Mr. J. K. Faulkner, B.Sc., Grad.R.I.C., Assistant Experimental Officer, Unit of Plant Nutrition, obtained the Grad.R.I.C. qualification after a Sandwich Course at the College of Technology, Bristol, and was then appointed from 1st July to replace Mr. B. L. Davies in the Organic Chemistry Section, during the latter's absence on National Service.

Marriage :

Mr. T. Ford, Clerical Officer, to Miss V. P. L. White, Accounting Machine Operator, on 26th September.

Deaths :

We are very sorry to have to record the deaths of three members or retired members of staff during the year. Mr. Douglas Stephens, who had been a worker in the Plantations for eighteen years, died after a short illness on 19th March. On the same day the death occurred of Miss E. M. Matthews, shorthand-typist in the office from 1935 until her retirement owing to ill health in 1957. Mr. Robert Jones, aged 84, collapsed and died on his way to work on 7th July, after thirty-seven years' service to the Station, first as plantations worker and, in recent years, as part-time maintenance worker.

Visits Abroad.

Dr. C. Bould and Dr. R. J. W. Byrde attended the 9th International Botanical Congress held in Montreal from 19th to 29th August. Both contributed papers and visited other research centres in Canada and the U.S.A. before or after the congress. Dr. Bould also took part in the Colloquium on Plant Analysis and Fertilizer Problems held in connection with the conference, and was appointed Honorary Secretary for the next Colloquium to be held in Belgium in 1962.

Dr. A. Pollard contributed a paper to the 5th International Fruit Juice Congress held in Vienna from 31st May to 8th June.

Mr. A. H. Williams attended meetings of the Plant Phenolics Group at University College, Dublin, on 10th and 11th September.

Miss Crang visited research centres in Denmark between 8th and 31st May at the invitation of the Danish Agricultural Producers' Information Service, as a representative of the Home Economics Association.

We are grateful to the Agricultural Research Council for grants towards the expenses of these visits and to the International Botanical Congress for inviting Dr. Byrde as a guest to their meetings.

Degrees, Honours, etc.

Mr. E. W. Hobbis was awarded the M.B.E. in the Birthday Honours List in June.

Dr. J. T. Martin was appointed Reader in Chemistry of Insecticides and Fungicides in the University of Bristol in July.

Mr. C. F. Timberlake was awarded the degree of Ph.D. (Bristol) for his thesis entitled "Studies of copper and its complexes in relation to storage changes in fruit juices."

Miss K. A. Taylor, Assistant Experimental Officer, Unit of Plant Nutrition, was awarded the London University external degree of B.Sc. (General) in August.

A Knighthood was awarded in the New Year's Honours List to Sir Geoffrey S. Peren, Principal of the Massey Agricultural College, New Zealand, a member of Long Ashton staff from 1920 to 1924.

Buildings and Land.

The Refectory was completed and handed over to the Station by the contractors, Messrs. John Knox Ltd., at the end of the year. It is a single-storied building of traditional style, with sloping ceilings, a heavy double-Roman tile roof, and a floor of polished Iroko wood blocks. It includes a dining hall, common-room, kitchen and food stores, entrance hall, office and cloakrooms. The dining hall is 60 ft. × 37 ft. approximately, the common-room 35 ft. × 37 ft.; the latter is of adequate size for most meetings and lectures, but larger gatherings can be accommodated by folding back partition doors dividing the dining hall and common-room, to provide a hall of 95 ft. × 37 ft. and 20 ft. high. It is provided with a hot-air circulatory system, giving rapid and uniform heating. The kitchen is well appointed with modern equipment, including an efficient air extraction system and refrigerated larder. The decorations and furnishings are in keeping with the high quality of the building. The Station is greatly indebted to the Agricultural Research Council for a grant and to the National Fruit and Cider Institute for a donation which have made it possible to provide a much-needed asset to the Station facilities.

During the year a central-boiler heating system was completed. This system provides space-heating and hot water for the Greenhouse-Laboratory buildings, the New Laboratories and the Refectory; it has spare capacity for heating other buildings. Steam is conveyed along underground conduits and supplies heat exchangers for the production of hot water, which is circulated through radiators or ceiling coils. Three automatically controlled, oil-fired McNeil boilers are sited in the boiler house of the greenhouses.

The extensive building programme in progress at the Station during the past few years has necessitated tidying the surrounds of new buildings. In 1959 work was started in the vicinity of the entrance to the Greenhouse and Biology Laboratories, and a car-park, road curbing, a drainage system for the removal of surface water, soil-retaining walls and paths were completed.

To meet the greatly increased use of electricity, the original main building was re-wired by the maintenance staff and a new underground supply cable was installed.

Although extensive grubbing of old orchards has been completed, there remains an acute shortage of suitable land for field experimentation. Some of the land which has been under fruit for many years is due for renovation by resting under grass. The Plant Pathology plot (23) was increased on the east side by $2\frac{1}{2}$ acres by planting land previously occupied by a tenant, and

the whole orchard of 11 acres has been re-fenced. On the north-west side of the farm, $1\frac{3}{4}$ acres of land have been purchased and will be used for nursery work after renovation.

Iron Ore Field, of some 20 acres on the north side of the farm, has been leased to the Forestry Commission ; it is unsuitable for fruit. All the building plots adjacent to Providence Lane have been let on ground leases, mostly to members of staff.

Open Days.

The Annual Field Day for Members and the Annual General Meeting of Governors and Members of the National Fruit and Cider Institute were held on 30th July. The laboratories, plantations and greenhouses were open for inspection and Members had the opportunity of seeing the work in progress. The conducted tours of orchard plots included demonstrations of black-currant and loganberry growing and developments in spray machinery. Exhibits were staged in the Cider House on fruit and foliar characteristics of commercial varieties of black currant and of *Ribes* species used for breeding purposes, the biology of the Big Bud mite of black currants, apple-juice blends, ciders and perries, and the assessment of quality in fruits for preserving.

Cider Sampling Day was held on 7th May. The programme included the sampling of single-variety perries and of cider and perries showing the effects of orchard factors on vintage quality. Other samples illustrated the uses of juice concentrates in cider making and of cull fruit in the production of ciders of high alcohol content.

Visitors.

The number of organized parties visiting the Station was 45, compared with 37 in 1958. Among the visitors were the British Mycological Society, the Commonwealth Education Conference, and a group of Oxfordshire and Berkshire fruit growers who had entertained members of the Plantations staff earlier in the year.

Organized Parties, 1959.

Ashton Gate Young Farmers' Club.
Bath College of Domestic Science (2).
Berkshire and Oxfordshire Fruit Growers.
Birmingham University : Biochemical Society.
Birmingham University : Honours Botany Students.
Bowden Hill Women's Institute, Chippenham.
Bristol Aeroplane Company : Apprentices.
Bristol Aeroplane Company : Wine Tasting Society.
Bristol Gardeners' Association.
Bristol Grammar School : Biology Students.
Bristol University : Honours Botany Students.
Bristol University Veterinary School : Centaur Society.
British Medical Association : Bath, Bristol and Somerset Branch.
British Mycological Society.
British Railways, Western Region : Staff Association.
Chelmsford and Maldon Fruit Discussion Group.
Colombo Plan Students.
Commonwealth Education Conference.
Domestic Food Preservation Courses : Meat (2).
Domestic Food Preservation Courses : Fruit and Vegetables (2).
Edinburgh University : Former Agricultural Students.
Exeter Training College.

Fraternity of St. Michael, Bristol.
Gardenhurst School, Burnham-on-Sea.
Hereford Training College.
King's School, Gloucester.
Long Ashton Women's Institute.
Long Ashton Young Wives.
M.A.F.F. Safety Inspectors : Spraying Course.
N.A.A.S. and L.E.A. Horticultural Officers : Refresher Course.
Newton Park College, Bath.
Nürtingen Horticultural College, Stuttgart, Germany.
Queen Elizabeth's Hospital, Bristol : Biology Students.
Ramblers' Association : Bristol District.
Reading University : Horticultural Students.
Red Maids' School, Bristol : Scientific Society.
Somerset Fruitgrowers' Club.
Waterperry Horticultural School.
Weston-super-Mare Grammar School for Girls.
Westwing School, Langford.
Wives' Fellowship : Bristol Branch.
Wotton-under-Edge Home Food Production Club.

Visitors from Overseas, 1959.

Australia : Dr. and Mrs. R. H. Best, Waite Institute, Adelaide.
Mr. B. A. B. Edwards, Merrindale Research Station, Victoria.
Mr. J. Giovanelli, University of Sydney.
Mr. D. L. Jones, Shell Chemicals Ltd., Brisbane.
Mr. and Mrs. E. Melville, Perth.
Burma : Mr. Salai Tun Than, University of Mandalay.
Canada : Miss Dorothy Britton, Summerland, B.C.
Dr. and Mrs. C. A. Eaves, Kentville, Nova Scotia.
Dr. J. Marshall, Summerland, B.C.
Mr. René Montpetit, Montreal.
Mr. Louis C. O'Neil, Sherbrooke.
Mr. Lorenzo Paré, Quebec.
Mr. W. R. Phillips, Plant Research Institute, Ottawa.
Mr. K. E. Winfield, Wakefield, Quebec.
Mr. G. E. Woolliams, Summerland, B.C.
Ceylon : Mr. E. Abeyaratne, Maha Illempallame.
Dr. E. D. C. Baptiste, Rubber Research Institute.
Mr. O. S. Peries, Rubber Research Institute.
Mr. U. Pethiyagoda, University of Ceylon, Colombo.
Denmark : Professor Sven Dalbro, Royal Veterinary and Agricultural College, Copenhagen.
Mr. Hans Gumpel, Technical University, Copenhagen.
Dr. Erik Poülsen, Blangstegaard, Odense.
Eire : Dr. G. A. Fleming, Johnstown Castle, Wexford.
France : Mme. Rose Mazoyer, Station d'Agronomie, Antibes.
Germany : Dr. F. Grüneberg, Hanover.
Professor F. Kruft, Nürtingen.
Dr. P. Schäfer, Berlin.
Dr. M. V. Schmieder, Steinbach-Straübing.
Dr. Günter Scholz, Gatersleben, East Germany.
Mr. Werner von Stritzky, Hanover.
Ghana : Mr. D. G. Howells, Ministry of Food and Agriculture.
Mr. E. S. Mason, Ministry of Food and Agriculture.
Greece : Dr. I. Porlingis, University of Thessalonica.
Holland : Mr. H. Jonkers, Wageningen.
Mr. G. S. Roosje, Wilhelminadorp.
Mr. W. P. N. Vlasveld, Wageningen.
Honduras : Dr. W. G. C. Forsyth, La Lima.
Hungary : Professor J. Konta, Charles University, Prague.
India : Dr. K. C. Bhan, Calcutta.
Professor M. P. Singh, Gwalior.
Mr. R. J. Sleigh, Andhra Pradesh.
Mr. A. R. Thapar, Simla, Himachal Pradesh.
Mr. L. V. Vaidyanathan, Bangalore.
Dr. J. S. P. Yadav, Dehra Dun.

Israel :	Mr. Harry Baumann, Daliah. Dr. S. M. Mayer, Hebrew University, Jerusalem.
Italy :	Dr. Antonio Ciccarone, University of Bari. Dr. V. Ignatieff, F.A.O., Rome.
Jamaica :	Mr. M. M. Hibbert, Citrus Growers' Association, Kingston. Mr. K. B. Martin, Yallah Valley.
Japan :	Mr. Kichimasa Hasegawa, Ihara Agricultural Chemical Co. Ltd., Tokyo. Dr. T. Hayashi, National Institute of Agricultural Sciences, Tokyo. Mr. M. Kushizaki, Kotoni, Sapporo. Mr. Hiroaki Nakamura, Agricultural Chemical Service, Tokyo. Dr. T. Nishikata, Hokkaido Experiment Station.
Kenya :	Mr. D. C. Attenburrow, Horticultural Research Station, Thika. Mr. E. Bellis, Department of Agriculture. Mr. J. A. N. Wallis, Coffee Research Station, Ruiru.
Malaya :	Dr. S. G. Boatman, Rubber Research Institute. Dr. V. M. Shorrocks, Rubber Research Institute. Mr. Ng Siew Kee, Department of Agriculture.
New Zealand :	Mr. T. F. A. Archer, Fruitgrowers' Federation Ltd., Nelson. Mr. J. L. C. Chaytor, Marlborough. Dr. L. W. Tiller, D.S.I.R., Wellington.
Nigeria :	Mr. B. O. E. Amon, Ibadan, W. Nigeria. Mr. and Mrs. E. C. Hislop, W.A.C.R.I. Mr. Emlyn Jones, Department of Agriculture, N. Nigeria. Mr. J. A. Makinde, Department of Agriculture, Benin, W. Nigeria. Dr. T. A. M. Nash, Kaduna, N. Nigeria. Mr. P. O. Park, W.A.C.R.I.
Norway :	Miss Else Flaatten, College of Domestic Science, Stabekk. Mr. M. Heggli, Agricultural College, Vollebekk. Mr. and Mrs. A. Nome, Räde. Mr. J. Ystaas, Ullensvang Research Station, Lofthus, Hardanger.
Peru :	Dr. P. de T. Alvim, Lima.
Poland :	Dr. M. Bielinska, Institute of Pomology, Skierniewice. Dr. O. Nowosielski, Warsaw. Professor J. Wierszyllowski, University of Poznan.
Portugal :	Dr. J. P. Amare, Beiras. Dr. J. de O. P. C. Contreiras, Sacavem. Mr. J. M. S. d'Arriago e Cunha, Sacavem.
Rhodesia :	Mr. W. J. Bassett, Inyanga, S. Rhodesia. Dr. J. S. Cole, Tobacco Research Board, Salisbury, S. Rhodesia.
Solomon Islands :	Mr. P. G. Fenemore, Department of Agriculture, Honiara.
South Africa :	Dr. P. Allan, University of Natal, Pietermaritzburg. Dr. D. K. Strydom, W.P. Fruit Research Station, Stellenbosch.
Spain :	Mr. F. Costa Yague, Murcia.
Sudan :	Mr. A. H. Ibrahim, Government Agricultural Chemist.
Tanganyika :	Mr. R. G. Tapley, Coffee Research Station, Moshi.
Trinidad :	Mr. D. H. Tucker, Department of Agriculture.
U.S.A. :	Professor J. T. Brann, Jr., Department of Entomology, Cornell University. Mr. G. T. Felbeck,, Jr., Department of Agronomy, Univserity of Delaware. Miss Mary Fisher, New York City. Dr. J. N. Goodman, University of Missouri, Columbia. Dr. Harry Kroll, New York City. Professor M. Rogosa, Bethesda, Maryland. Dr. L. Southwick, Midland, Michigan. Mr. J. R. G. Sutherland, New York. Dr. J. F. Thompson, Cornell University, Ithaca. Mr. K. H. Wieschhoff, Brunswick, Maine.
U.S.S.R. :	Mrs. M. Chinenkova, Moscow. Dr. V. N. Evminov, Western Ukraine. Dr. N. Melnikov, Institute for Insectofungicides, Moscow. Miss Murzaneva, State Scientific and Technical Committee, U.S.S.R. Council of Ministers. Dr. V. Simonev, Institute for Insectofungicides, Moscow.
Zanzibar :	Dr. F. L. Vanderplank, Department of Agriculture.

Shows and Demonstrations.

Exhibits were staged during the year as follows :—

Royal Horticultural Society, Chelsea, May 26th–29th : Gooseberries.
Commonwealth Fruit Producers' Conference, London, June 9th–19th : Apple juice products.
Malvern Fruit Conference, November 3rd : Apple juice products.

Students and Voluntary Workers.

We are very sorry to have to record the death on 22nd April, 1959, in the U.S.A., of Dr. Antonia Maria Medina Ortega, biochemist from the Instituto de Edafologia y Fisiologia Vegetal, Madrid. Dr. Antonia Medina was awarded a British Council scholarship in 1955 to work with Dr. Nicholas on the metabolism of nitrogen compounds in micro-organisms. Because of her outstanding work the Institute provided a further grant to enable her to complete her biochemical studies at Long Ashton, which she did in June 1957. During her happy and fruitful stay she published no fewer than eight scientific papers and matured into a first-rate biochemist. Dr. Antonia Medina was an able and a dedicated worker, always enthusiastic and hard working, and held in high esteem by all who came in contact with her. Her untimely death is a sad loss to all who were privileged to know her.

Dr. Olgierd Nowosielski, University of Warsaw, Poland, spent three months from 19th January training with Dr. Nicholas, Unit of Plant Nutrition. Dr. Nowosielski held a Rockefeller Foundation Fellowship, under which he had spent three months at the University of Wisconsin, U.S.A., before coming to Long Ashton.

Mr. C. E. C. Bartlett and Mr. J. C. Caseley commenced two-year periods of study under the direction of Mr. Marsh and Dr. Luckwill on 14th September and 5th October respectively. They are graduates of Wye College, London University, and have been awarded Ministry of Agriculture Scholarships for two years to study for M.Sc. degrees. Mr. Bartlett's work will concern physiological aspects of the storage life of apples, and Mr. Caseley is studying herbicides and their potential uses on fruit crops.

The Boots' Research Scholarship for the two years commencing 1st October, 1959, was awarded to Mr. C. F. Cresswell, M.Sc., Rhodes University, South Africa, who has been working at Long Ashton for the past two years in the Unit of Plant Nutrition. He is continuing his studies under the direction of Dr. Hewitt.

Mr. L. V. Vaidyanathan, an Indian trainee under the Colombo Plan, worked with Dr. Bould from 20th July to 19th September ; his period of training is being shared by Rothamsted Experimental Station and Long Ashton, and he will be returning to Long Ashton for further work with Dr. Bould in the spring.

Professor J. Wierszyllowski, who holds the Chair of Pomology in the College of Agriculture of the University of Poznan, Poland, worked with Dr. Luckwill from 29th August to 27th October, under a British Council bursary. He was primarily concerned to learn the techniques of auxin extraction and bioassay which have been developed at Long Ashton.

Mr. Francisco Costa Yague of the Centro de Edafologia y Biologia Aplicada del Segura, Murcia, Spain, spent from 3rd July to 30th October with Dr. Hewitt and Dr. Nicholas, studying micro-nutrient methods.

Miss E. Conroy, Department of Soil Chemistry, Eire Ministry of Agriculture Laboratories, Johnstown Castle, Wexford, Eire, received an eight-week period of training in October and November in culture methods for plant nutrition studies, under the direction of Dr. Hewitt. Miss Conroy was accepted for this training at the request of Dr. T. Walsh, Director of the newly-constituted Agricultural Institute in Eire, which is assuming responsibility for research on soils, plant and animal nutrition.

Mr. J. Dacoutros of Malta commenced on 24th September a six months period of study of the principles of fermentation in the Cider and Fruit Juices Section under the direction of Dr. Pollard.

Mr. W. von Knapitsch of Austria gained general experience in the Cider House and laboratories of the Cider and Fruit Juices Section for one month ending 14th November.

Mr. J. A. Worle, a nominee of Somerset County Council, held the Memorial Studentship in Cider-making for the six months ending 30th September, 1959, and received instruction in cider orcharding during that period.

In addition to the above, the following postgraduate students continued their investigations at the Station during the year :—

Miss M. F. Roberts, holder of the Boots' Scholarship until 31st October : Chemistry Section.

Mr. Khan Afridi, Aligarh Muslim University, India : A.R.C. Unit of Plant Nutrition (Micro-nutrients).

Mr. M. W. Case, holder of a Ministry of Agriculture scholarship, completed his studies in the Pomology Section in June 1959. He was awarded the degree of M.Sc. in Bristol University for a thesis entitled " A study of pear rosette : a nursery disorder affecting certain pear varieties when worked on to Quince stocks."

Mr. P. G. Burgess, Mr. M. A. Rashid Khan and Mr. K. Pirozynski attended Long Ashton during the summer term as part of their training for the Diploma in Plant Pathology.

Miss M. A. Carter of the Botany Department, University of Bristol, on 1st October commenced collaborative work with Dr. Byrde on *Nectria* canker.

Mr. E. D. Evens, B.Sc. (Bristol), continued his voluntary assistance in Dr. Woodcock's laboratory, and the Station is greatly indebted to him for his valuable help in organic syntheses.

Social Activities.

The completion of the Refectory was celebrated by the annual staff Christmas Dinner, held on 23rd December in the unaccustomed spaciousness of our new dining hall. This was the first occasion on which the building had been used and, although it was not then fully equipped, the labours of Miss Batcheller, the Domestic Supervisor, Dr. Woodcock, Chairman of the Refectory Committee, and many others, made it possible for 150 staff to enjoy an excellent lunch. The occasion was an especially happy one as the three Directors—past and present—of the Station were guests of the staff. With the accommodation now afforded by the Refectory–Common Room, it will be possible for the Station's social activities to be extended and improved, and a number of clubs are already planning to make use of it for meetings, talks, concerts, etc.

The Recreational Club, with a membership of about 190, has under the Chairmanship of Dr. Bennett again provided for a wide range of tastes : as well as talks and visits to local theatres and places of interest, there have been longer excursions to the Shakespeare Memorial Theatre, Slimbridge Wildfowl Trust and Westonbirt Arboretum. A Photographic Section has been formed, and in addition to talks and colour-slide shows, darkroom facilities have been provided for members' private photographic work. The Christmas Party was again organized by the Club at Messrs. Wills' Recreation Hall, Bedminster, on 22nd December. The gramophone and recording equipment was installed in the Common Room in December, and the piano very kindly presented to the Station by Mrs. Greenwood will soon be placed there.

The Tennis Club membership continued to increase, and reached the record number of fifty-five, which, combined with the fine summer weather, resulted in greater use being made of the courts than usual. In spite of this, the record of our two league teams was disappointing, as staff changes have meant the loss of several of our best players : the Men's Team was relegated to Group VI ; the Ladies' Team retained a place in Group VI. Fifteen friendly matches were played, of which four were won.

The Cricket Club, in spite of a reduced fixture list and shortage of players, had a moderately successful season and won nine of the fifteen matches played. Particularly pleasing was a narrow victory over our friends from the National Vegetable Research Station, Wellesbourne. The club were sorry to lose the services, through resignation from the staff, of M. W. J. Heyes and N. T. Weatheritt, both of whom played a large part in the revival of the club in recent years.

The Table Tennis Club arranged several friendly games with other clubs during the winter, and later in the year a staff competition was organized.

The Rifle Club continued to use the O.T.C. indoor range at the University for small-bore rifle shooting during the winter months, and the outdoor range at the Station during the summer, where both full-bore and small-bore pistol shooting are now enjoyed throughout the year. The use of Pilning ranges was again obtained for full-bore rifle shooting. The National Rifle Association Donegall Badge for 1959 was awarded to Mr. Victor W. L. Jordan by the Club's President, Professor Kearns, at the conclusion of the Christmas Dinner.

Miss Margaret Kieser succeeded Dr. Bennett as Chairman of the Welfare Committee, which met four times during the year to consider matters affecting the health and comfort of staff. During the year the Chairman started the practice of sending a letter of welcome to each new member of staff on appointment, giving information about Station amenities, social activities, membership of Clubs, etc. The Chairman has also arranged gifts, visits and letters to those who had been absent through illness for any length of time.

Dr. Woodcock continued as Chairman of the Canteen Committee—renamed Refectory Committee. With the appointment of Miss Batcheller to supervise catering, the Committee's work will in future be mainly confined to responsibility for the financial administration of the meals service.

The Chairmanship of the Library Committee was taken over by Dr. Burroughs during the year. With the transfer of the canteen to its new premises, the Library Committee plan to extend the old library to the adjoining rooms ; a programme of much-needed refurnishing and redecoration is envisaged.

Two new committees were formed during 1959 : a Sports and Social Club Committee to co-ordinate applications for financial assistance from Station funds by the various clubs already in existence, and a Laboratory Services Committee, under the chairmanship of Dr. Martin, to consider suggestions for improving services and promoting safe working in the laboratories.

The annual sports fixture with the National Vegetable Research Station was held in Bristol on 27th June, when thirty-three members of the Wellesbourne staff were entertained to lunch in the Senior Common Room and took part in tennis and cricket matches at the University playing fields at Coombe Dingle. The cricket match was won by Long Ashton and the tennis by Wellesbourne.

Acknowledgments.

The Station is indebted to the members of staff who have served on the staff committees, particularly to their Chairmen : Dr Bennett (Recreational Club), Dr. Burroughs (Library), Miss Kieser (Welfare), Dr. Martin (Laboratory Services) and Dr. Woodcock (Canteen).

The transition at the end of the year from the Canteen to the Refectory was accomplished smoothly, thanks to Miss Batcheller for her rapid organization of the kitchen and catering services, and to Miss Simpson for her advice on furnishings and decorations. The Station is also greatly indebted to Miss Karen Taylor, Mrs. Hunt and Miss Leach, who were responsible for arranging the menus during the year. To Mrs. King and Mrs. Duddridge must be accorded grateful thanks for their excellent cooking in the former Canteen : their achievement in cooking for so many in such a small, inadequately equipped kitchen for fifteen years cannot be over-estimated.

The Station would also like to thank Mrs. Alvis, who acted for Miss Crang during her illness in July and August, and made it possible to hold two courses in Fruit and Vegetable Preservation ; Mr. Greenwood, for his advice and guidance as Editor of the Annual Report ; and Mr. Mapother, for taking over the technical direction and organization of photographic work.

Once again the maintenance section undertook a very heavy programme of work, and thanks are due to Mr. S. E. Cole and Mr. H. J. Jones and their staffs. Thanks are also due to Dr. Morgan, Mr. E. A. Fribbins and Mr. J. H. Russell for their advice and material assistance to many members of staff in the numerous problems that require the services of the workshops.

SUMMARY OF RESEARCH, 1959.

Pomology and Plant Breeding.

Plant Breeding.

The *Ribes* collection was further augmented and a start was made with the screening of the various species for disease resistance and other useful characters. Forty interspecific crosses were attempted, with *Ribes nigrum* as the female parent; hybrid seedlings have been obtained from some of these crosses, but others failed owing to pollen or zygote incompatibility. Sixteen black currant progenies have been raised by crossing four leading varieties in every combination, with the objects of assessing the comparative values of the varieties for future breeding programmes, and of producing new varieties.

Top-fruit breeding has been limited to the production of three families of perry pear seedlings. Ten out of 53 of the 1947 series of cider seedlings which fruited this year were retained for further trial. To aid the preliminary evaluation of these seedlings, spot tests for assessing acid and tannin levels in the fruit have been developed.

A series of controlled pollinations in several orchards confirmed the almost complete self-sterility of the pear variety Conference. In most orchards no fruit was set after selfing, but in one a high proportion of fruit with low seed number was produced. When Conference was pollinated with the varieties Laxton's Superb, Williams' Bon Chrétien and Doyenné du Comice, fruit-sets of 33%, 24% and 21% respectively were obtained, which indicate that the female gametes are viable. In an investigation of techniques for the study of pollen tube growth, aniline blue, which contains a callose-staining component that fluoresces strongly in ultra-violet light, has been found particularly suitable for staining apple pollen tubes in the style. A second technique that has been developed involves the labelling of the pollen with ^{32}P (see Physical Chemistry).

Growth Substances.

In collaboration with the Chemistry section, studies of the metabolism of 2,4-dichlorophenoxyacetic acid (2,4-D) in the leaves of currants, apples and strawberries were extended to include other substituted phenoxyacetic acids labelled with ^{14}C in their carboxyl groups. Varieties capable of decarboxylating 2,4-D could also decarboxylate 2,4,5-trichlorophenoxyacetic acid (2,4,5-T), 4-chlorophenoxyacetic acid (4-CPA) and 2-methyl-4-chlorophenoxyacetic acid (MCPA). Failure to decarboxylate 2-chlorophenoxyacetic acid was attributable to the fact that 80-90 per cent. of this compound was utilized in the formation of water-soluble metabolic products, whilst most of the remainder was bound to the leaf structure, possibly as a protein complex. It was found that varieties resistant to 2,4-D were often killed by low concentrations of 2,4,5-T, even though both molecules were decarboxylated at similar rates, suggesting that damage from the latter compound is caused by a breakdown product. In apples, comparatively high rates of decarboxylation of 2,4-D were recorded for 11 varieties having Cox in their parentage, whereas 13 varieties not related to Cox showed low rates of decarboxylation.

Sprays of gibberellic acid, either alone or in combination with the auxin 2-naphthoxypropionic acid, set a full crop of parthenocarpic fruit in the pear varieties Laxton's Superb and Williams' in which pollination had been

prevented by excising the styles. Of six apple varieties tested, four showed some initial response to gibberellic acid, but only in Miller's Seedling were mature parthenocarpic fruits produced (p. 59).

For the third year in succession 1-naphthalene acetamide (NAm) at 25 p.p.m. was applied as a fruit thinning spray to the same branches of the apple variety Crawley Beauty. The sprays induced the desired degree of thinning each year, but there has been a progressive reduction in the numbers of large ($> 2\frac{1}{2}''$) fruits harvested. The overall effect for the three years has been a reduction in the numbers of small fruits but no significant difference in the numbers of large fruits per 100 blossom clusters (p. 64). In a further thinning trial with Crawley Beauty, whole trees sprayed with NAm showed the same response as the branch units normally used for trials with fruit thinning chemicals. The strictly localised effect of the treatment was confirmed in an experiment with Laxton's Superb in which distal and proximal halves of branches were sprayed with 1-naphthalene acetic acid. No effect on fruit-set or fruit size was noted on the unsprayed portions of the branches.

Records from black currant plots that had been sprayed the previous year with γ-(2,4,5-trichlorophenoxy)butyric acid (2,4,5-TB) and γ-(4-chloro-2-methylphenoxy)butyric acid (MCPB) for the control of *Convolvulus arvensis*, showed that cropping on all the sprayed plots was improved, as compared with cultivated control plots, even though July applications of MCPB had caused considerable damage to the bushes.

In trials of residual herbicides in fruit tree nurseries, mixtures of 2,4-dichlorophenoxy ethyl sulphate (2,4-DES) applied at 4 lb. per acre with N-(4-chlorophenyl)-NN′-dimethylurea (monuron), 2-chloro-4,6-bis-(ethylamino)-s-triazine (simazin) or sodium 2,2′-dichloropropionate (dalapon) at 2 lb. per acre, gave good control of annual weeds without damage to the crop. 5 lb. per acre of dalapon applied in March or April was found to give a satisfactory control of couch grass (*Agropyron repens*) amongst cordon apple trees, without completely killing the grass cover; by this means re-invasion by other weed species was avoided.

Physiology of fruit plants.

Apple seedlings and trees in pots have been grown under warm white fluorescent lights in the controlled environment rooms. Light intensity (approx. 1,500 foot candles) has been found to be a limiting factor for growth of apple at temperatures above 5°C., but trees have flowered and fruited successfully in the chambers. Differences in the time of bud break, in the proportion of buds breaking, and in the size of the flower parts, have been noted between trees in the chambers and those growing under normal field conditions; the causes of these differences are being investigated.

Studies of the relationship between shoot and fruit growth in the apple var. Lord Lambourne indicate that the early stages of fruit growth depend on reserves of food materials stored in the tree from the previous season. Carbohydrates from vegetative shoots of the current year enter the fruits only after the growth rate of the shoots has started to decline. A vigorous vegetative shoot growing from a bourse can cause fruit abscission.

Work on the effect of nitrogen on fruit set in apples under conditions of self-pollination has shown that, although ability to produce seeds is little

affected by nitrogen, fruit set may be greatly increased by nitrogenous dressings, particularly those applied the previous summer. With such treatments even self-sterile varieties may produce an economic crop without cross-pollination.

Variety trials and cultural experiments.

The development and propagation of a virus-tested sub-clone of the East Malling loganberry L.478 was described in the 1957 Report : mainly by leaf-bud propagation, 5 leaf-bud cuttings from one virus-tested plant were increased to 800 in two years. Three hundred of these plants were supplied to the Nuclear Stock Association for field propagation. The Ministry of Agriculture has instituted a Certification Scheme for this particular stock of loganberry, under the number LY 59, and large numbers have been propagated. At Long Ashton, 450 plants, planted $8' \times 6'$ in the spring of 1958, cropped for the first time in 1959 and yielded $10\frac{1}{2}$ lb. of marketed fruit per plant or 4·2 tons per acre. Three methods of training are under trial : (a) open fan with new canes tied up the centre ; (b) full fan with new canes held along bottom wire ; (c) full fan with new canes along the ground (p. 78).

Rootstocks and Propagation.

An M.I stoolbed infected with latent rubbery wood virus four years ago has shown a yield reduction of 29 per cent. compared with control beds free from this virus. The crop from M.VII stoolbeds has been reduced by only 2 per cent. as the result of infection.

Forty clones of the Malling series of rootstocks have been indexed for latent virus using *Malus platycarpa* as indicator. All the clones induced symptoms of line pattern, scaly bark or dwarfing, with the exception of M.XVI and M.XII. Of nineteen clones of the Malling Merton series of stocks, all except 5 clones of MM.109 and one clone of MM.106 were found to be free from latent virus.

All the main dessert, culinary and cider apple varieties indexed on *Malus platycarpa*, with the exception of the cider variety Court Royal, have shown varying amounts of infection. No infection has been found in unworked seedling apples. *Malus platycarpa* line pattern virus has also been found in Victoria plum showing line pattern symptoms, and in Bristol Cross pear showing ring spot symptoms. The possibility of inactivating these latent viruses in apple by heat therapy treatment is being investigated.

The trial of apomictic seedling rootstocks, now in its seventh year, is reported on p. 50. Cox's Orange Pippin and Lord Lambourne have cropped more heavily on *Malus sikkimensis* than on M.II, but Worcester Pearmain crops have been heavier on M.II. Cox, Worcester and Lambourne all proved incompatible with the triploid and tetraploid forms of the apomictic *Malus Sargentii*.

Fourteen species of *Sorbus* and eight species of *Pyrus* have been tested as possible seedling rootstocks for pears. All the *Sorbus* species showed incompatibility with Conference, and the *Pyrus* species, although compatible, were rejected because of the uneven vigour of the seedlings.

As part of an investigation into the possibility of using anatomical features for the selection of seedling rootstocks for cider varieties, the variation

in root anatomy of certain clonal stocks grown in different environments was studied. The data have been sent to Rothamsted for processing in an electronic calculator.

Cider and Perry Varieties.

Interest in perry pear planting has been maintained and much attention has been given to the problems concerned with the propagation and orcharding of perry pears. The survey of farms growing perry pears was continued : a further 115 farms in north Gloucestershire were visited and several varieties of merit, not previously recorded, were found (p. 68). Further pomological descriptions of perry pears were completed for publication (p. 71). Demand for perry propagating material has been heavy, and during the year 9,500 grafts and 4,500 bud sticks were sent out to growers. Unfortunately much of this material is known to be virus infected, but observations on the growth of maiden trees budded in 1958 have enabled the healthiest material to be selected for future propagation.

A scheme has been started for the distribution to nurserymen of virus-tested scion mother trees of certain cider varieties. These trees are free from rubbery wood, chat fruit and mosaic viruses, and represent a big improvement on the propagating material previously available. It is hoped to extend the range of virus-tested varieties offered to nurserymen.

Attention has been given to the planning of new cider and perry orchards, taking into consideration manufacturers' requirements, pollination and orchard management. Two further trials of standard cider trees have been planted, one in Somerset and one in Gloucestershire, to compare the vigour and cropping of varieties on a range of seedling and vigorous clonal rootstocks, using two stembuilders. There has been an increase in the number of enquiries from Cider Institute members and others concerning cider and perry orcharding. Sixteen enquiries were dealt with by letter or visit, some in collaboration with the N.A.A.S.

Plant Nutrition : Fruit.

Field Experiments.

The long-term nutritional and cover crop experiments at Long Ashton and the N.A.A.S. Experimental Horticulture Stations at Efford and Luddington have been continued. In the factorial NPK black currant experiment at Efford yield responses were obtained from soil applications of phosphate and potash but not from the higher rates of nitrogen. Leaf analysis in 1958 indicated that the concentration of phosphorus and potassium, in bushes from NK and NP plots respectively, was below normal : leaf-nitrogen was satisfactory. The lack of response to nitrogenous fertilizer is thought to be partly due to water deficiency. In a similar experiment at Luddington there was no response to fertilizer treatments. Leaf analyses indicated a higher phosphorus and potassium status than in comparable material from Efford (p. 84).

The second phase of the factorial NPK experiment on strawberry under cloches was started at Rosewarne Experimental Horticulture Station. Four new experiments (in collaboration with Mr. F. A. Roach of the N.A.A.S.), designed to study the effect of time of application of nitrogenous fertilizer on

strawberry, were started at Efford, Rosewarne, Fairfield and Terrington Experimental Horticulture Stations.

In the apple cover crop experiment at Long Ashton (Plot 18) trees on rye and timothy plots made better growth than in previous seasons and responded to additional dressings of nitrogenous fertilizer. Differences in growth, crop yield and leaf nutrient status due to cover crop were still appreciable. Growth and crop yield were directly related to leaf-nitrogen concentration, the relative order being : clover>tumble down>timothy>rye. There was a marked accumulation of phosphorus and potassium in the leaves of trees on the timothy and rye plots.

The early lateral growths of fruiting canes in the raspberry deficiency experiment at Long Ashton (Plot 17) were abnormal, the symptoms resembling the condition known as " dwarf lateral scorch." Crop yields were affected and no detailed records were taken.

Pot Experiments.

A comprehensive factorial sand-culture nutrition experiment was carried out with strawberry, var. Royal Sovereign, to investigate (a) the main effects and interactions of N, P, and K, each at three levels, on growth and crop yield, and (b) the relationship between leaf nutrient concentration, at different growth stages, and plant performance. By including additional treatments in the deficiency and excess regions it was possible to calculate " response surfaces " (see Statistics Section). Preliminary analysis of the yield data showed significant main effects due to nitrogen and potassium, and a significant N×K interaction. There was no response to increased levels of phosphorus : leaf analysis indicated, however, that the lowest level of nutrient-phosphorus produced luxury levels of leaf-phosphorus (>0·35% P in dry matter at the fruiting stage). Nutrient treatments produced significant main effects and interactions in leaf nutrient status at flowering, fruiting and after fruit picking. Increasing the potassium in leaf dry matter, at the fruit ripening stage, from 1·4 to 1·8% increased the total yield of fruit, but had no significant effect on yield of grade I fruit. Further increasing the potassium in leaf dry matter to 2% had no additional effect on crop yield. There were also indications from the leaf analyses that optimum yields of fruit were associated with a leaf N P ratio approximating 10.

The effects on growth, crop yield and leaf composition, of varying the K/Mg relationships of strawberry, var. Royal Sovereign, were also investigated. There was a significant increase in crop yield and total dry matter associated with an increase in leaf-potassium, at the fruit ripening stage, from 1·37 to 1·86%. At the same stage, the leaf K/Mg ratio could be varied from 3 to 14, and the leaf-magnesium concentration from 0·14 to 0·39% in dry matter, without any significant effect on crop yield. It would appear from these results that the strawberry has a relatively low requirement for magnesium. No magnesium deficiency symptoms appeared at the lowest concentration of leaf-magnesium (0·14% dry matter).

The effect of boron on the growth and composition of strawberry plants grown in water and sand culture was studied, over the range nil to slight excess, to try to find the cause of certain abnormal leaf symptoms, similar to those of boron deficiency, that had occurred under field conditions. The field

samples contained from 40 to 50 p.p.m. of boron in leaf dry matter. Plants grown in culture solution without boron, and showing typical boron deficiency symptoms, contained from 3 to 4 p.p.m. of boron in leaf dry matter, while plants making normal growth contained from 23 to 46 p.p.m. of boron in leaf dry matter. It would appear from these results that boron deficiency was not the cause of the abnormal field symptoms.

The first stage in a raspberry nutrition experiment was completed. Canes of the variety Lloyd George were potted in sand culture, and given complete nutrients to establish them prior to differential nutrient treatments in 1960.

In collaboration with the Chemistry Section, work has been continued on the behaviour of iron chelates within plants. This has included the use of iron chelate solutions doubly-labelled with the radio-isotopes ^{14}C and ^{59}Fe, applied to plants either in nutrient solutions or as foliar sprays. When leaves in the middle region of extension shoots of chlorotic apple trees were sprayed with double-labelled Fe-EDTA or Fe-CDTA solutions, no movement of ^{59}Fe was detected outside the treated leaves, but there was a small amount of ^{14}C activity in the leaves above those treated. This was confirmed by a newly-developed autoradiographic technique in which aluminium foil was used to filter the radiation of ^{14}C from that of ^{59}Fe. Changes were observed in the ratio of ^{14}C to ^{59}Fe in nutrient solutions containing Fe-EDTA in which tomato plants were growing. The ratio was initially 5:1, but after 10 weeks' growth the plants contained the isotopes in the ratio of approximately 2·5:1, while in the residual culture solution the ratio had increased to approximately 10:1.

Laboratory Investigations.

Work on leaf analysis as a guide to the nutritional status of fruit crops was continued. To determine whether any loss of nitrogen occurs on prolonged storage of dried leaf samples, samples of apple, black currant and strawberry leaves were dried initially at 65°C. and 105°C. After drying, some samples were stored in a refrigerator and some in the laboratory at room temperature. The nitrogen concentration in the samples will be determined at intervals over a period of two years. No significant loss of nitrogen has yet occurred, after a period of five months storage.

A comparison was made of four methods for the determination of boron in pure solutions and in plant material. The 1, 1′-dianthrimide method was found to be generally the most satsifactory. Further investigations have been made of the Titan yellow method for determining magnesium in plant material; as now modified this method is as accurate as the volumetric 8-hydroxyquinoline method. Analyses have been made for N, P, K, Ca, Mg, B, Cu, Fe and Mn in samples of plant material in collaboration with the A.R.C. Group on Comparison of Methods of Analysis of Mineral Elements in Plants.

A method was developed for separating iron chelates from plant material with columns of activated charcoal on which the chelates are retained and from which they can be eluted with 25% ethanol. By this treatment many interfering substances are removed, and it is hoped that the chelates, or their metabolites, can be identified chromatographically.

In preliminary investigations of the nitrogen nutrition of fruit trees, 3-year old Worcester trees grown in sand-culture showed a great increase in the percentage of alcohol-soluble nitrogen at blossom time, even under restricted nitrogen supply.

Chemistry.

Organic Chemistry.

Work was continued on the metabolism of organic compounds by *Aspergillus niger*. The as yet unknown compound 1-hydroxy-2-naphthyloxyacetic acid, which is possibly a metabolic product of 2-naphthyloxyacetic acid, is of interest as a potential plant growth regulator. So far four synthetic routes to this compound have been investigated without success. The synthesis of γ-(6-hydroxy-2-naphthyloxy)-β-hydroxy-*n*-butyric acid is in progress in order to confirm the identity of a transient intermediate in the metabolism of γ-(2-naphthyloxy)-*n*-butyric acid. An investigation of the metabolism of 2,4-dichlorophenoxyacetic acid by the fungus was begun, using a replacement culture technique. Chromatographic evidence was obtained of two major phenolic products.

Eight members of a series of 2,4-dinitro-6-*n*-alkylphenyl crotonates have been prepared for an investigation into the fungitoxicity of Karathane (2,4-dinitro-6-(1-methylheptyl) phenyl crotonate). Preliminary tests against apple mildew suggest that the crotonic acid residue may be relatively unimportant structurally. Other compounds prepared for test against apple mildew included diphenylacetic acid, di-*p*-chlorophenyl and di-*p*-nitrophenylacetic acids, 2,3-dichloro-1,4-dihydroxynaphthalene crotonate and two choline-acetylation inhibitors, diphenyl-*n*-pentyl and diphenyl-*n*-heptylacetic acids. The synthesis of 2,4-dinitro-6-(1-methylheptyl) phenyl crotonate is in progress.

Continuing the investigation into the roles played by chelation and lipoid solubility in the fungistatic activity of 8-hydroxyquinoline, eight 6-alkyl-8-hydroxyquinolines were synthesized for assay using a mycelial growth test.

After considerable development work the Körbl method was adopted for the estimation of carbon and hydrogen in organic compounds.

Physical Chemistry.

Work with radioactive tracers was carried out in collaboration with other Sections. With the Pomology Section the study of the metabolism of 2,4-dichlorophenoxyacetic acid in leaves, using ^{14}C, was continued and extended to include other substituted phenoxyacetic acid herbicides (p. 22). In further work on the influence of applications of 2-naphthaleneacetic acid (NAA) on the uptake of $^{14}CO_2$ by leaves of apple trees, no consistent effect attributable to NAA was detected. For studies of incompatibility in the apple, pollen was labelled with ^{32}P by standing shoots carrying blossom clusters in radioactive nutrient solution. The viability of the pollen was unaffected by labelling, and the growth of the pollen tube down the style was readily followed.

With the Entomology Section radio-active phosphorus was used to investigate the behaviour of the Black Currant Gall mite, which becomes radioactive when fed on shoots grown in a nutrient solution containing ^{32}P.

Work with the Fruit Nutrition Section on the uptake and metabolism of iron chelates labelled with ^{14}C and ^{59}Fe was continued (p. 27), and assistance was given to the Plant Pathology, Physiology and Chemical Microbiology Sections in the preparation and assay of solutions containing ^{14}C, ^{32}P and ^{59}Fe.

A gas phase scintillation counting technique for ^{14}C assay, based on a method developed in the Botany Department of the University, has proved much more sensitive than end-on window counting of barium carbonate and requires less manipulation.

Investigations were continued on dynamic surface tension, an important criterion of the efficiency of wetters. The vibrating jet method for its determination was further refined and a study of aqueous solutions of surface active compounds of practical importance was begun. Dilute aqueous solutions of sodium alkyl sulphosuccinates were found to reach equilibrium tensions in 80 milliseconds after surface formation ; a difference in behaviour was observed between the dinonyl and diethylhexyl compounds.

The toxicities to *Alternaria tenuis* of salts of twenty-five metals were determined. A direct relationship was found between the toxicities of the metal ions and their electronegativities. This suggests that the primary toxic action of all the cations results from physical adsorption involving non-specific reactions with surface ionogenic groupings of the cell. The uptake of copper from aqueous solutions by spores of *A. tenuis* and *Neurospora crassa* was found to be greater than that needed for enzymatic poisoning. Experiments with ^{64}Cu showed that after absorption the copper was not preferentially associated with particular cell components. Dead cells took up copper as efficiently as living ones, indicating a physical effect independent of metabolic processes. The uptake of captan (N-trichloromethylthio*cyclo*hex-4-ene-1,2-dicarboxyimide) by spores of *N. crassa* was found to be temperature-dependent and to be reduced in the presence of respiration inhibitors such as cyanide and arsenite and of the sulphydryl compounds glutathione and cysteine. By comparison with living cells, negligible amounts of captan were taken up by dead ones. The absorption of captan by the spores therefore seemed to be dependent on cell metabolism.

An investigation was begun of the relationship between the particle size distribution of captan suspensions and their tenacities on apple, coffee and other leaves.

Analytical and General Chemistry.

Work on the determination of micro quantities of dieldrin and endrin was continued. A second analytical method for spray residues of dieldrin was developed, using catalytic quantities of sulphuric acid to convert dieldrin into a *gem*-diacetate from which the corresponding ketone and subsequently a 2,4-dinitrophenylhydrazone were formed. The orange colour developed on treating the hydrazone with tetraethylammonium hydroxide was measured at 440 mμ. The possibility of modifying the method to make it suitable for the estimation of endrin is being investigated. The boron trifluoride method for the estimation of dieldrin (Report for 1958) was, with slight modification, found satisfactory for the determination of traces of endrin, though less sensitive than for dieldrin (*55). An investigation was begun of the factors

* *See* Publications, 1959, pp. 168-171).

affecting the efficiency of alumina in reducing interference by plant constituents in the analytical methods.

Considerable attention was given to spray deposits of mercury because of its toxicological importance. The analytical method for mercury in plant material was critically examined and the behaviour of mercury applied to apple, bean and broccoli plants was followed (p. 93). Analyses of apple bark were made for the Plant Pathology Section to assess the retention of mercury used as an eradicant fungicide for canker control. Conjoint work was carried out with the Mercury Panel of the Ministry of Agriculture, Fisheries and Food Scientific Sub-committee on toxic chemicals.

Spray deposits of zineb (zinc ethylene-1,2-bisdithiocarbamate), ethylenethiuram monosulphide and derris were examined. Considerable variations in deposits of zineb on black currant leaves were found, according to the surface-active agents used. Ethylenethiuram monosulphide and derris deposits showed poor persistence on plants in the open (p. 100). The method for the analysis of captan by reaction with pyridine and tetraethylammonium hydroxide after minor modification was used successfully for the determination of captan spray deposits. Work was begun on the chemical assay of Karathane deposits and the micro method for sulphur (Annual Report for 1956) was re-examined. Soils were assayed for DDT for the National Vegetable Research Station.

Studies on cuticles were continued. The wax and cutin deposition was followed in apple leaves of increasing age and the effects of differing environmental conditions upon wax and cutin formation in the apple leaf were investigated. A detailed study was made of the waxy and cutin components of the cuticles of different varieties of apple fruit, and of the changes in the cuticles of the fruits in storage (p. 106).

Plant Pathology.

Work was continued on the effects of different carbon and nitrogen sources on the production of polygalacturonase by mycelium of the brown rot fungus *Sclerotinia fructigena*; effects of nitrogen sources on growth were also tested on cultures of the canker fungus, *Nectria galligena*. The method of origin of *Nectria* cankers in apple tree crotches was investigated (p. 112).

The newly-introduced fungicide *n*-dodecyl guanidine acetate (dodine, Cyprex, Melprex) showed no obvious phytotoxicity on nine commercial apple varieties, including Stirling Castle: on Cox it induced slight russeting. Conference pears sprayed at the fruitlet stage were seriously damaged.

Winter applications of 0·1% dinitro-*ortho*-cresol in 3% spindle oil reduced primary outbreaks of apple mildew on extension shoots. This reduction was largely a consequence of the penetration and killing of mildew-infected buds by the DNC-oil, particularly when applied in March. In the exceptionally early spring of 1959, some healthy buds were also killed by the March application. The effects of winter DNC sprays in controlling mildew were found to be much less important than those of summer sprays with lime sulphur or Karathane (p. 115). The reduction of apple mildew noted in 1958 as a consequence of over-all tipping of extension shoots in the winter of 1957-8 did not persist into 1959.

Gloeosporium perennans infected leaf-scars of Cox at leaf-fall in mid-November, but not subsequently. Fruit rotting by *Gloeosporium* was found to be least in apples from trees at a normal level of nitrogen ; both extreme nitrogen deficiency and nitrogen excess increased the tendency to rot. Fruit from trees pruned in both summer and winter was less susceptible to infection than that from trees pruned only in winter. Analyses were made of bark treated with mercurial fungicides, to determine the persistence and effectiveness of the mercury in the host tissues against *G. perennans*.

In trials at Efford Experimental Horticulture Station on the control of black currant leaf spot by summer spraying, two pre-cropping and two post-cropping sprays were used. Baldwin was more heavily infected than Mendip Cross, but the two early sprays with zineb reduced the infection by 64% compared with a reduction of 39% with captan. Post-cropping sprays were slightly less effective. The results of winter treatments in 1953-59 have been summarized (p. 118).

At Luddington Experimental Horticulture Station, trials on strawberries showed that better mildew control resulted from spraying with thiram plus lime-sulphur than from thiram plus Karathane or thiram alone. Tainting was noted in canned strawberries from thiram-sprayed and lime-sulphur-sprayed plots. At Long Ashton, mildew infection of strawberry stolons, leaf-stalks and fruit-stalks was found, and the perithecial stage of the causative fungus (*Sphaerotheca humuli*) was recorded on strawberry for the first time in Britain.

In spraying trials against strawberry *Botrytis*, Karathane and griseofulvin both gave a moderate, but significant, degree of control ; dodine (Cyprex) and sorbic acid sprays were ineffective (p. 123).

The results of spraying trials on Leveller gooseberries at Efford were : Karathane-sprayed plots, total crop 379 lb., mildewed 0·1 lb. ; washing soda, 335 and 0·4 lb. ; control, 400 and 10·2 lb.

In work on the fungistatic action of mineral oils, banana leaves (variety Cavendish) were successfully inoculated at Long Ashton with conidia of *Mycosphaerella musicola*, the fungus causing banana leaf spot. Dyes suitable for use with the mineral oils have helped to demonstrate the behaviour of oil applied to the leaves.

Entomology.

Biology of Insect Pests.

Observations were continued at Long Ashton on the leaf hoppers attacking the cider apples Sweet Alford and Stoke Red and the dessert apple Laxton's Superb ; apart from lime-sulphur given to the Laxton's, the trees received only a spray of BHC-DDT-succinate on April 23rd. As in 1958, the uni-voltine *Erythoneura alneti* was the most common species ; nymphal stages were present from May 11th to July 17th, adults were recorded from mid-June and egg-laying was first observed in late September. Other species that over-wintered on the apple were *Typhlocyba froggatti* (which hatched at the same time as *E. alneti*), *Empoasca flavescens* and *Erythroneura angusta*. Second in importance to *E. alneti* was *Typhlocyba debilis*, which flies onto the apple from rosaceous plants in June and produces two or more generations. Adults of *T. rosae* also fly onto the apple and produce one generation of adults by August or September ; it is impossible to distinguish nymphs of this species from those

of *T. froggatti* which produces one generation and a partial second one on apple. In addition to the work at Long Ashton, population studies were made in unsprayed apple and plum orchards in Devon, Dorset and Gloucestershire. On loganberries at Long Ashton a few adults of *T. rosae* and *T. debilis* were found in the summer; on black currants *E. alneti* was recorded early and *T. rosae* and *T. debilis* later in the season.

In a study of the damage caused to fruit trusses of Cox's Orange Pippin by the Rosy Apple aphid (*Sappaphis plantaginea*) it was found that no permanent damage was caused if the aphids were controlled up to the early pink bud stage. Where a single fundatrix remained on a truss until 70% petal fall the fruit was malformed and parthenocarpic; aphids that remained until 14 days after petal fall caused extensive malformation of the fruit.

In further work with the Willows Section on the biology and control of the Willow beetle (*Cryptorrhynchus lapathi*) adults found in early spring were still surviving at the end of summer. The average number of eggs laid was about 50; these hatched during the late summer and autumn. Estimates of the population and movement of beetles in willow beds, using a capture-recapture method, showed that the population density was uniform and that there was little movement between plants. There was no evidence under field conditions that gamma-BHC, applied early in May to rods 4-6″ long, gave any control of the beetle.

The investigation of the biology of the Black Currant Gall mite has been continued, with emphasis on those aspects of mite behaviour most likely to determine the precise targets and time of application of spray materials for effective control. It has been shown that the mites, when migrating from infested buds in the spring, are attracted towards the light and therefore to the outside of the bush, where they are more readily picked up and transported by visiting insects. The distribution of the mites within the bush and to adjacent ones results partly from their leaping habit and partly from their being washed down by rain on to new basal shoots. An increase in temperature accelerates the emergence of the mites from a bud and the humidity largely determines the chances of survival when in transit to a new axillary bud; a high humidity prolongs their life (p. 130). The extreme sensitivity of individual mites makes it nearly impossible to follow their movements under the binocular on the host plant; this difficulty has been overcome by tagging a group of mites with radio-active ^{32}P. The transmission of the virus of Reversion by the mite, insects and mechanical means is under examination.

Bio-assays of insecticides and fungicides.

The effect of aldrin on the respiration of the cockroach, *Periplaneta americana*, has been investigated. The symptoms of poisoned insects indicate a mode of action different from that of DDT, although the sequence of events—inco-ordination, paralysis, and death—is superficially similar. The oxygen consumption of the adult showed a sudden increase to approximately five times the normal rate, after a latent period of several hours or days, according to the dosage; this was followed by a slow decline until death. This is similar to the results obtained with DDT and shows a strong correlation between the respiration rate and the insecticide-induced activity of the insect. The

respiration, measured as oxygen uptake, of thoracic ganglia from DDT-poisoned insects showed a change of rate with change of activity similar to that of the adult, the maximum ganglia respiration being double the normal rate. Only a slight increase was found in the respiration rate of thoracic ganglia from insects poisoned with aldrin. It would appear that an increase of the respiration rate accompanies the action of aldrin but it is less than that induced by DDT and not so definitely correlated to the activity of the adult. Increased oxygen consumption occurs also in the latent period before symptoms appear.

Spraying trials were carried out with the non-poisonous contact insecticide pyrethrum, in view of the need for information on the value of non-persistent insecticides of low mammalian toxicity as alternatives to spring washes now used on fruit crops. Field trials some 25 years ago had shown that, although pyrethrum was a good aphicide, it failed to give effective control on apples; it was not clear whether this was due to faulty formulation and application. Emulsions of extracts containing 0·0025% and 0·005% pyrethrins were compared with those of DDT alone applied at 0·025% and a combination of DDT/BHC (0·025% DDT/0·007% gamma BHC). The emulsions were formulated similarly with solvent naphtha and sulphite lye emulsifier; all the sprays were used with 0·025% Manoxol N. The sprays were applied to full coverage by hand-lance to Cox trees at the green cluster and pink bud stages. A complete control of aphids was obtained with each emulsion applied at each stage, whereas on unsprayed trees the percentage of flower trusses infested was 59. Further work is in progress to assess the value of pyrethrum and other materials when applied by small volume spraying methods.

New information on the migration of Black Currant Gall mites and their entry into axillary buds suggested further trials of weak lime sulphur as a means of control. Drenching applications of 1% lime sulphur, made at several stages in the season by hand-lance and by overhead automatic boom, were compared with a single hand-lance drenching application of 2% lime sulphur at the grape stage. Excellent control of the mite was obtained by the repeated applications, and no phytocidal effect or significant depression of fruit yield was observed. Work in progress is aimed at developing this technique to the commercial stage.

Small scale trials, with apples grown in pots, confirmed the previous finding that chlorbenside, applied with a succinate wetter at the pink bud stage of Worcester, gives a good control of Fruit Tree Red Spider mite if the winter eggs are thoroughly wetted. Poor control was obtained when the blossom trusses and foliage were wetted but not the eggs.

Spray Techniques.

Further study has been made of the effects of surface-active agents, incorporated as stabilizing and wetting agents in emulsions and suspensions, on the deposition of spray materials. Spray deposition is influenced by the physical and chemical reactions that take place between the surface-active agents and the leaf surface. Typical recoveries of a tracer dye dissolved in the oil phase of an emulsion sprayed to complete wetting on apple leaves were: anionic wetter = 0·150 μg./sq. cm.; non-ionic wetter = 0·200 μg./sq. cm.; cationic wetter = 0·350 μg./sq. cm. of leaf. Unlike the anionic and non-ionic wetters, small changes in structure or concentration of cationic wetters have

a marked effect on the amount of deposit. Methods of measuring the degree of wetting are being surveyed ; they include visual assessment with and without the use of fluorescent tracers, and measurement of contact angles.

A flying spot particle resolver has been installed for the rapid automatic sizing of droplets of 1 μ and upwards in emulsions and atomized sprays, and of particles in suspension. It is anticipated that this instrument will make it possible to carry out investigations on spray droplet behaviour that have hitherto been impossible. Techniques for presenting samples to the instrument are being developed.

The difficulty of rapidly and accurately assessing the pattern of distribution and level of spray deposits has been overcome by the inclusion of suitable fluorescent tracers in the spray formulation. The behaviour of tracers in droplets of 25-50 microns, which are at the lower limits of visibility, was examined, particularly as it was suspected that non-visible but biologically active material might be present on the target. A close relationship was found between the levels of spray deposits determined by chemical and fluorescent assays. This rapid method of examining spray deposits is a valuable aid for testing the behaviour of spray machines (p. 103).

Preparatory work was undertaken at Long Ashton as a basis for field investigations in North Borneo of methods for spraying tobacco for the control of Frog Eye disease. It was found essential to add a wetter to the fungicide to ensure even distribution on the leaf surfaces. The relation between the concentration of the spray and the level of deposit obtained on leaves, when applied by means of a knapsack mist-blower, was determined.

Investigations were continued in collaboration with the Department of Agriculture, Kenya, on the control of *Pseudotheraptus* Nutfall Bug of coconuts by means of DDT sprays. The levels and fate of spray deposits on the coconut spadices were ascertained and correlated with their toxicity to various instars of the bug. Numerous samples of plant material were sent to Long Ashton by air freight for assay of DDT. It was evident that the residual deposit from a 1·0% DDT spray remained available and toxic to the bugs for a maximum of only seven days.

Spray Machinery.

A brass pneumatic hand canister sprayer was designed for the spraying of coconut spadices by climbers. The canister is pumped-up by a foot pump and fitted with a safety valve, wide-angle flat spray nozzle, thumb-operated release tap and a clip for easy attachment to a waist belt. Every item of the sprayer was made for easy operation and to withstand rough usage ; the total weight was 3 lb. Twenty-four were made for experimental work in Kenya.

Experimental work was continued on methods of forming reasonably close spectra of small droplets, using sonic speeds of compressed air in twin-fluid nozzles and projecting liquid films into air sheets of 150-200 m.p.h. velocity.

A tractor-mounted sprayer was built, incorporating a 60 c. ft. compressor, two masts of compressed-air nozzles (Annual Report for 1957), a spray tank and a centrifugal pump. The machine gave a uniform droplet distribution on the foliage of apple trees on a still day, and merits further field trial, especially with small bush fruits.

An electrically driven, moving slit droplet sampler has been evolved for field studies on sprays ; field studies have been continued on the design of mist-blower nozzles for the application of sprays on tobacco in North Borneo, and a complete set of spray nozzle assemblies has been made for the automatic application of artificial rain to tropical plants in the Palm House at the Royal Botanic Gardens at Kew.

Cider and Fruit Juices.

Organic Components.

Work on the nitrogenous constituents of apple juices now indicates that the protein fraction is extremely small and that part of the alcohol-insoluble nitrogen fraction is of lower molecular complexity, probably of peptide nature. The true protein, amounting to less than one milligram per 100 ml. juice, appears firmly attached to the juice phenolics and is not separated by dialysis even under reducing conditions. These complexes remain insoluble after dialysis.

More detailed study of the interactions between sulphur dioxide and juice constituents has called for more sensitive methods of analysis of free and bound sulphur dioxide. A polarographic method has been investigated (63) and a modification of a colorimetric method using pararosaniline and formaldehyde has been developed that will estimate amounts less than 0·1 mg.

Work on the non-volatile organic acids of cider-apple juices and ciders has been continued and the earlier work published. Benzoic acid, previously noted in fermented ciders, has now been found present in juices, the amounts being of the order of 0·01 milliequivalents per 100 ml. of juice. A number of unidentified acids also occur in juices in trace amounts in addition to those noted in earlier reports (65, 66).

It has been found that the total amounts of keto acids present in juices are small and of the order of 200 μg. per 100 ml. The presence of α-ketoglutaric, pyruvic and oxaloacetic acids has been confirmed, but it is now doubtful whether glyoxylic acid, tentatively identified in the juice, is present. The main keto-acid formed during fermentation is pyruvic acid, the amount produced (up to 0·1%) being greater in high-nitrogen juices than in those of low nitrogen content. Gluconic acid has also been found to increase in amount in sulphited fermentations in addition to those acids previously reported. The mono-, di- and tri-galacturonic acids have now been isolated from ciders and characterized. These arise from pectin breakdown by yeast polygalacturonase (47).

It has been found that the main neutral carbonyl compound present in sulphited ciders is L-xylosone ; this compound is probably formed by oxidation of L-ascorbic acid rather than by the oxidation of xylose, which has been found to be present in cider-apple juices in the D-form.

The volatile carbonyl compounds present in juices are being studied by gas chromatography. The presence of acetaldehyde as a main component of the volatile fraction of perry pear juices has been confirmed. It has been found that the occurrence of formic esters during the chromatographic separation of alcohols on polyethylene glycol columns, as reported by other workers, is to be attributed to the production of formic acid in unpurified samples of such glycols.

Work on the metabolism of caffeic acid by *Lactobacillus pastorianus* var. *quinicus* has been extended to related substances (67). Cinnamic acid was reduced by the organism to dihydrocinnamic acid (isolated in 85% yield). *p*-coumaric acid was reduced to phloretic acid and 60% of the latter was de-carboxylated to ethyl phenol. Neither acrylic acid nor coumarin (*o*-coumaric lactone) was attacked.

Unfermented juices.

The need for a more efficient utilization of second-grade apples has revived interest in apple juice as an outlet for such fruit. Commercial varieties in main supply have been found suitable for the production of opalescent apple juice of Canadian type : preliminary tests have been followed by more extensive trials at Long Ashton in collaboration with the Metal Box Co. Ltd. and more recently with other commercial organisations (p. 139). A range of products has also been produced using apple juice as a base but with various admixtures of other fruits (p. 145). Other small-scale tests are in progress to obtain basic data on the chemical and microbiological aspects of production, the effects of fruit variety, fruit maturity and processing methods.

Non-enzymic oxidation in juices.

Work has continued on the stability of ascorbic acid in black currant juices and model systems, in relation to their metal content, and in conjunction with other work on the complexing of copper and iron. Using model systems and the Warburg technique, it was found that although certain metal chelating agents inhibited the oxidation of ascorbic acid catalysed by copper, varying amounts of oxidation could still occur in the presence of iron. At low iron levels (7 p.p.m.) ascorbic acid oxidation was very slight. Of those chelating agents tested which were effective against copper, only DTPA (diethylene-triamine penta-acetate) was effective also against larger amounts of iron (56 p.p.m.) ; others (CDTA, EDTA and DPTA), increased oxidation at this iron level. Findings were similar with black currant juices. An account of this work is in the press.

The analysis of fruits and juices of eight varieties of black currant has given further information on their natural content of copper and iron that will be helpful in assessing contamination by spray residues.

A rapid method of estimating iron in cider and similar products, without preliminary destruction of organic matter, is in course of development. In this method, the red complex formed between ferrous ions and 4,7-diphenyl-1,10-phenanthroline is extracted into chloroform and compared with colours obtained with standard amounts of iron.

Fermentation of concentrates.

The use of juice concentrates by the cider industry, for subsequent dilution and fermentation to cider, promises many advantages, particularly the extension of the fermentation season. It has, however, raised both chemical and microbiological problems. Excessive oxidation of the juice during concentration leads to a lowering of cider quality, but the complete suppression of oxidation by the addition of sulphur dioxide during juice extraction gives ciders lacking

in flavour. The addition of sulphur dioxide to the pressed juice is preferable : it has the added advantage that, if the sulphited juice is held for one or two days before concentration, the pectin present is sufficiently degraded by the juice pectin esterase to permit its removal by yeast enzymes during fermentation (47). Ciders prepared from juice concentrated immediately after pressing were found difficult to filter because of the presence of residual pectin. The removal of pectin by the addition of commercial enzymes before concentration gave ciders of inferior quality.

Microbiological studies showed that the numbers of yeasts present after concentration were very low : bacterial numbers were also low and did not increase after dilution and fermentation. Yeasts did not increase in number in concentrates stored at 50°C. if the specific gravity were greater than 1240 (at room temperature the critical specific gravity would be 1320). The fermentability of diluted concentrates, both by the natural flora and by yeasts in pure culture, was found to be lower than that of the original juices. Storage of the concentrates reduced still further their capacity to support yeast growth after dilution. Comparative tests of the same juice concentrated in a pilot plant and under commercial conditions indicated that concentrate prepared with the minimum oxidation (pilot plant) subsequently fermented more readily and supported a greater yeast population : the ciders were also of better quality.

General microbiology.

A number of microbiological advisory problems have been examined, and critical reports on several cider factories have been prepared at the request of the managements. The examination of ciders made from batches of the same fruit at Long Ashton and in one of the factories showed qualitative and quantitative differences in their microflora. The factory juice gave a poorer cider and needed a greater amount of sulphur dioxide to improve quality and stability. Changes subsequently made in the factory methods and equipment have given better ciders at a greatly reduced cost.

Studies of the acetic acid bacteria, made in collaboration with Dr. J. L. Shimwell of British Vinegars Ltd., have re-affirmed the original discovery by Leifson that these bacteria are not a homogeneous group, but may be divided, on the basis of flagellation and behaviour towards acetate, into the two genera *Acetobacter* and *Acetomonas*. A joint study of *Acetomonas* strains has shown that the two strains *A. suboxydans* and *A. melanogena* are so closely related as no longer to justify their separation (15).

One new species isolated from cider corresponded in all characteristics to *Acetobacter mesoxydans* but had the added ability to produce starch, a property hitherto only associated with *Acetobacter pasteurianus*, from which it differed, however, in other respects. In view of the extreme mutability of *Acetobacter* species, which makes their classification by conventional means virtually impossible, it is not proposed to name this or subsequently discovered species.

The mutation of acetobacters from one species to another by the loss or gain of various biochemical activities has often been observed. The discovery in the present work that mutants of the new species can lose the ability to oxidise alcohol to acetic acid is the first occasion on which loss of the generic characteristic has been noted. During this work abnormal structural

forms of the organisms and unusual colonial characters have been observed : their significance is being investigated.

The behaviour of a strain of *Acetobacter rancens*, obtained from Switzerland and known there as *Bacterium sylvane*, has been studied in both small-scale trickling and submerged aerated vinegar generators. In the former the perfusion of the wood-wool packing with substrate encouraged the development of mutants that produce extra-cellular polysaccharides that attach the bacteria to the packing. In submerged culture, interruptions of the air supply encouraged the appearance of mutants incapable of oxidizing alcohol but able to oxidize acetic acid.

Domestic Food Preservation.

The effects of deep-freezing and of canning under domestic conditions on the ascorbic acid contents of vegetables have been tested by comparing the values for different varieties when freshly picked, and when scalded prior to preserving, with those obtained after storage ; the canned vegetables and brine were tested before and after re-heating and the frozen vegetables before and after cooking. Whilst the losses of ascorbic acid in preserving varied considerably from one kind of vegetable to another, losses in deep-freezing were considerably less than those in canning. Forty varieties canned and frozen in 1958 were tested during the current year, and a further 30 varieties were preserved for subsequent testing. Quality assessment of the colour, texture and flavour of preserved vegetables has again been made.

Fruit varieties whose ascorbic acid content and pH value were determined, as well as their quality when fresh and preserved, have included apples, blueberries (p. 151) and strawberries from the N.A.A.S. trials at Faversham, Wareham and Starcross and 35 varieties of gooseberries grown at Long Ashton. The colour of many of the fruit and vegetable varieties was recorded by means of the Lovibond-Schofield Tintometer, so that changes during storage could be noted.

In further attempts to detect whether the fungicides captan, Karathane, lime sulphur and thiram have any effect on the flavour of preserved fruits, known amounts of these substances have been added to acidified sugar syrups and to mixtures of the syrup with unsprayed strawberry purée. The canned and bottled mixtures were stored at 25°C. and the frozen ones at –20°C. for several months before examination. An average of 15 members of staff, forming a tasting panel, each tasted 56 triangles comprising a treatment and control, the order of tasting being arranged by the Statistics Section. Strawberries sprayed with these fungicides have also been tested for flavour when fresh, canned and frozen, and as jam (see Plant Pathology). Iron determinations were made on all the canned fruit and syrups, to see whether the fungicides accelerated corrosion of the can. Though 5 p.p.m. of captan and 1 p.p.m. of thiram were detected in some of the canned acidified syrups, they were less noticeable in the mixtures containing strawberry purée. Karathane appeared to have no adverse effect on the flavour or on the containers. Sprayed black currants and gooseberries have been preserved for similar examination.

A fall in the heat-resistance of the stock culture has caused temporary delay in completing work on the heat-resistance of bacterial spores in bottled and canned vegetables. Studies of microbiological changes during the freezing and thawing of foods have been continued.

Willows.

Variety Collection.

Cuttings of four American species containing a high proportion of salicin in the bark were received, and a further three selected fast-growing hybrids from Germany, bringing the total number of varieties in the collection to 196. Differences of sex, bark colour and leaf habit, found amongst individuals of the so-called hybrid *Salix aquatica gigantea* received in 1957, have now appeared at other centres.

Experimental Work.

Further measurements were made of the root development of basket willows planted at Long Ashton in 1954. The mean weights of root per stool during the six successive years have been 6·5, 8·8, 38·3, 120, 276 and 413 grams ; as in 1958, 60% of the roots were found in the surface 6″ of soil.

Work on the control of Greater Bindweed encircling willow shoots was continued. Foliar applications of from 250 to 1,000 p.p.m. 2,4,5-trichlorophenoxybutyric acid (2,4,5-TB) proved damaging to young shoots of potted willows (var. Black Maul) treated in May and June, and to rods of 34″ sprayed in the field in July ; the highest rate caused premature leaf fall and considerable die-back. Damage was also caused by the June spraying of second-year rods (var. Newkind) that averaged 4½ ft. in height.

Good control of couch and other grasses in willow beds was obtained by the use of 4 lb./100 gall./acre 2,2′-dichloropropionic acid (dalapon) at the end of May, though better results were obtained from 6 and 8 lb./acre. Two varieties of *Salix viminalis* showed temporary leaf scorch, but no damage was observed on any of 25 varieties of *S. triandra*.

Studies of the etiology of willow rust, *Melampsora amygdalinae*, have been made, in collaboration with the N.A.A.S., on 15 willow beds varying in age from one to ten years. Although the season was unfavourable to rust development—the mean number of cankers was only 0·04 per rod—teleutospores were found on 98% of leaves at the end of the season. In preliminary trials of nickel as a systemic fungicide for willow rust, it was found that potted willows would tolerate foliar applications of 50 ml. of a solution containing up to 290 p.p.m. nickel. Young unsprayed shoots from plants treated with solutions containing 145 p.p.m. nickel contained 45 p.p.m. nickel, compared with 1·5 p.p.m. in untreated controls.

Work on the Willow beetle, *Cryptorrhyncus lapathi*, is described under Entomology (p. 32).

In further experiments to break the dormancy of cut willow rods, attempts to replace the cold period (Report for 1958) by treatment with gibberellic acid were unsuccessful. The best of the treatments advanced the peeling date by only 5 weeks compared with 10 weeks using the 1958 procedure.

Tests of cutting machines at Long Ashton and in Somerset willow beds have shown that cutting is greatly facilitated by close planting, which induces a more upright habit. The density in the Somerset beds is 17,000 stools per acre compared with 4,840 at Long Ashton.

Advisory Work.

There were 187 requests for information during the year. 74 advisory visits were made as below :

	South-West	*Home Counties*	*East Anglia*	*Midlands*	*North*	*Wales*	*Scotland*	*Foreign*
Enquiries	62	30	18	14	16	6	9	32
Visits	62	5	0	3	2	1	—	1

Four-fifths of the enquiries were concerned with basket willows and one-fifth with tree willows for cricket bat manufacture or the production of pulp or similar products ; foreign interest in the last was notable.

There were 11 requests for planting material from research and education centres, including 5 from Rural Secondary Schools wishing to establish small beds to provide material for their Handicrafts Section. Numerically the most important was for 10,000 cuttings to extend the Lancashire County Council scheme noted last year. The Prison Commission planted a further area in Suffolk, but owing to the exceptionally dry season growth was poor, particularly in local depressions. The overall growth of the areas planted in 1957 and 1958 was again good but the poor patches noted in 1958 in areas of impeded drainage have persisted ; these areas have a high salt content.

Though imports of foreign willows have remained relatively stable there has been a 40% increase in imported basketware and this, coupled with the decline in the number of basket makers, has depressed the demand for home-grown willows. In consequence the prices at the Somerset auctions again averaged only £40 per acre and, though the acreage auctioned was only half that of 1958, the proportion unsold increased from 44% to 47%. In terms of processed willows, the price per bundle has fallen from 35/- to about 25/- since 1957. It is now no longer economic to retain old willow beds and in Somerset 133 acres were taken out in 1959 compared with 57 acres in 1958, none in 1957 and 22 acres in 1956. 14 acres were planted in 1959, bringing the total acreage in the county to 1206 (p. 155).

The exceptional season produced a light crop of high quality, the average rod being more than one foot shorter than usual. There was a virtual absence of stem cankers caused by Willow rust. The Willow beetle was of widespread occurrence but was only locally abundant. Aphids were especially numerous in September, but did little damage because willow growth terminated three weeks earlier than usual.

Interest in willow for the production of pulpwood and similar products is increasing both at home and on the continent, where collections of selected natural varieties and strains are being made. In association with the Forestry Commission sufficient material has been accumulated to plant a small trial area with six species to test their capacity as pulpwood produoers.

The six hardy selections from the Long Ashton collection supplied to the Forestry Commission in Devon, to test their potentialities as soil improvers

at exposed sites, have made satisfactory growth ; *Salix daphnoides* was outstanding, producing 1-2 shoots, 5½ feet long, per stool.

Statistics.

Experimental Design and Analysis.

Assistance in the planning of experiments and in the preparation of data for publication has again been given to Station staff and to University research workers, particularly in Veterinary Science. An experiment with onion seed dressings was designed and analysed for the Horticultural Science Laboratories, Bracken Hill.

Long-term experiments planned for the Long Ashton plantations include designs for alternative uses of the large area shortly to be replanted. Several orchards in the West Midlands made available for studies of the effect of nutrient status on pollination have been surveyed, and trials arranged on suitable portions of the existing plantings.

A large amount of data was obtained from the greenhouse experiment on strawberry nutrition designed by the " response surface " method (p. 26) ; a detailed report will be made on the statistical aspects of the trial, which was arranged to compare this method with the classical factorial design under controlled environmental conditions. If the results are successful, the size of experiment needed for this type of nutrition study may be reduced appreciably.

An experimental design has been discovered which possesses some of the orthogonality characteristics of Graeco-Latin squares, but is based on a Youden square instead of a Latin square. The possibility that a class of such designs exists is being examined.

A report has been prepared of the statistical methods used to find the important sources of variation in the chemical analysis of leaf samples.

Biometric Studies.

The tasting panel has continued to assess fruit samples from field trials of fungicides, and has also examined further sets of artificially-flavour-based solutions containing fungicides, preserved by different methods ; a report will be prepared when the tasting of samples preserved from the 1959 crop has been completed.

Black currant leaf spot assessments have continued at Long Ashton and at other experimental sites with the aid of the Long Ashton charts (Annual Report for 1955), which have now been used successfully by many observers. Pathological trials are under observation as well as variety plots.

In the study of droplet shapes (Report for 1958) a general cardioid has been fitted to typical data with only limited success ; further mathematical problems are entailed. This work, carried out in collaboration with Rothamsted Experimental Station, has been delayed by shortage of staff on the electronic computer, as has the search for measurements suitable for differentiating between rootstocks (p. 25).

Plant Physiology.

It has been found that the synthesis of nitrate reductase *in vivo* in detached cauliflower leaf tissues is inhibited by patulin and kynurenine, which may be

analogues of tryptophane, and by canavanine, which is an analogue of arginine. Cysteine hydrochloride and thiol analogues of cysteine also inhibit the formation of the enzyme. Serine and tryptophane increase the capacity of infiltrated leaves to respond to both nitrate and molybdenum as inducing factors. Actidione, already shown to inhibit synthesis when infiltrated into leaves, is also inhibitory to synthesis of the enzyme by nitrogen-deficient plants, when taken up by roots for 48 hours at a concentration of 100 μg/ml.

Hydroxylamine reductase extracted from vegetable marrow or wheat has been shown to require manganese for activity. Preparations from manganese-deficient plants are inactive unless manganese is added to the extract; a dissociable system is indicated. Magnesium does not replace manganese. The effects of age and leaf position on activity in marrow resemble those observed for nitrate reductase. The enzyme is apparently decreased in extracts from molybdenum-deficient plants grown with nitrate.

Nitrite reductase activity has been observed in particulate and soluble fractions from rice, wheat, marrow and cauliflower. Undetermined factors cause great variations in observed activity in different fractions.

Specific activities of aldehyde oxidase of potato have been increased 110 times. Evidence for a metal component is still inconclusive, but inhibiting effects of azide and of thiocyanate, both of which are reversible, are consistent with the presence of a functional metal.

Histological studies of the lesions occurring in early stages of whiptail in molybdenum-deficient cauliflower grown with ammonium sulphate suggest that semipermeability of cell membranes is impaired and chloroplast disintegration occurs. These effects are not usually seen in leaves of molybdenum-deficient plants grown with nitrate.

Work on the uptake of oestrogens by plants has been undertaken jointly with Dr. R. F. Glascock of the National Institute of Research in Dairying. Preliminary results indicate that although root uptake of hexoestrol is negligible, retention by contaminated foliage may be significant. Further work is in progress.

An automatic surface irrigation method applicable to micronutrient deficiency studies has been devised and is under test. Methods for growing cauliflower in sand culture under sterile conditions to prevent nitrification have been tested, and further work is in progress.

Chemical Microbiology.

Nitrate Assimilation.

Nitrate reductase was much reduced in mutants of *Neurospora crassa* grown at suboptimal levels of either adenine, uracil, methionine, histidine, or tryptophane. Enzyme production was markedly inhibited either by adding ammonium chloride or 2,4-dinitrophenol, *in vivo*, to felts grown in a medium containing sodium nitrate or by growing felts at low oxygen tensions. None of the 15 organic nitro-compounds tried induced enzyme formation in the felts.

Nitrification in Soil Bacteria.

Nitrosomonas europaea, which oxidises ammonia to nitrite, was kindly supplied by Dr. Jane Meiklejohn of Rothamsted Experimental Station. It

has been grown at Long Ashton, using an automatic titration unit to maintain the pH at 8·0 ± 0·1, and also in batch culture at the Medical Research Council's Antibiotics Research Station, Clevedon, through the courtesy of the Director, Mr. B. Kelly. Cell-free preparations of the bacteria, prepared by ultrasonic disruption of the cells, oxidized hydroxylamine to nitrite in the presence of a suitable acceptor such as phenazine methosulphate, pyocyanine, methylene blue, benzyl viologen or mammalian cytochrome c ; but ferricyanide, 2,3,6-trichloroindophenol dye, coenzymes I and II, methyl viologen or glutathione were without effect. With cytochrome c as the acceptor there was a phosphate requirement, but at higher concentrations phosphate inhibited the enzyme as did a number of other anions including pyrophosphate, citrate, selenate, tungstate and arsenate. The phosphate inhibition, which occurred when cytochrome c was the acceptor, is competitive. Hydrazine, known to inhibit nitrite production from hydroxylamine in whole cells, had a similar effect on the cell-free system when cytochrome c was used, but it was without effect when phenazine methosulphate was the acceptor. Although ammonia was not oxidized by these extracts, its addition stimulated the conversion of hydroxylamine into nitrite. A 50-fold purification of the enzyme system has been achieved by ammonium sulphate precipitation and treatment of the fractions on columns of diethylaminoethylcellulose.

Nitrobacter agile, which oxidises nitrite to nitrate, has also been grown in batch culture both at Long Ashton and at Clevedon. Cell-free extracts of the bacteria, prepared by ultrasonic treatment, oxidize nitrite to nitrate. The addition of ferric chloride to these extracts stimulated enzyme activity about ten-fold.

Denitrification in Soil Bacteria.

Pseudomonas aeruginosa gives maximal production of nitrogen from nitrate when grown anaerobically at 37°C : gas evolution was negligible below 20°C. The production of cytochrome c (E. max. 552 mμ) by the bacteria was markedly increased under anaerobic conditions.

A very active nitrate reductase, purified more than 100-fold from cell-free extracts of bacteria disrupted with the ultrasonic probe, requires reduced diphosphopyridine nucleotide (DPNH) as the hydrogen donor and contains flavin adenine dinucleotide (FAD) and sulphydryl groups. Its activity is markedly reduced in bacteria deficient in either iron or molybdenum. Iron labelled with ^{59}Fe accumulated in purified fractions of the enzyme. The affinity of the enzyme for its substrate is high : K_m (nitrate) $= 1{\cdot}6 \times 10^{-5}$ M/litre.

An enzyme that reduces nitrite to a nitrogenous gas is also present in cell-free extracts ; it requires DPNH or TPNH and is markedly stimulated by additions of flavin mononucleotide (FMN) or FAD. A 20-fold purified enzyme has been prepared that will utilize neither DPNH nor TPNH, but the reduced forms of FMN or FAD or pyocyanine were effective donors for nitrite reduction.

Nitrogen Fixation in Soil Bacteria.

Cells of *Azotobacter vinelandii* (O strain) grown in a well aerated nitrogen-free medium were disrupted in the culture medium in which they were grown, either by treating them with egg-white lysozyme or with the ultrasonic probe.

Cell-free extracts from either treatment were prepared by centrifuging at high g values. These extracts were exposed to a gas mixture containing the stable isotope, $^{15}N_2$. Disruption of the cells appeared not to affect the nitrogen fixing mechanism since enrichment with the isotope was similar to that in whole cells. Even after high-speed centrifugation the incorporation of $^{15}N_2$ into the cell-free extracts was quite substantial. This would appear to be the first unequivocal demonstration of the incorporation of $^{15}N_2$ into cell-free extracts of a nitrogen fixing organism.

Biochemistry.

Observations on the oxidation-reduction properties of illuminated chloroplasts and of chloroplast extracts have been continued. The chloroplast protein fraction shown to be active in mediating reduction of metmyoglobin, when reduced triphosphopyridine nucleotide (TPN) serves as hydrogen donor, has now been partially purified. It is readily separated, by ammonium sulphate fractionation, from another chloroplast protein fraction already known to be active in catalysing the reduction of a variety of haemprotein compounds, including metmyoglobin, when hydrogen is donated by illuminated chloroplasts.

During further studies of this latter reaction it was found that the purified protein involved is also highly active in catalysing the photochemical reduction of TPN. It is inactive towards diphosphopyridine nucleotide. The rate of reduction of TPN is increased up to 2·5-fold when the photochemical reduction is coupled to photophosphorylation by including a phosphate accepting system (adenosine diphosphate, Mg^{++}) in the reaction mixture. The product of phosphorylation was identified as adenosine triphosphate (ATP). Haem-protein reduction, on the other hand, has not so far been shown to be coupled to photophosphorylation. Although it cannot be stated with certainty that the catalytic activities towards haem-proteins and TPN are properties of a single protein, attempts to separate the activities by fractionation procedures have so far proved unsuccessful. The highest rates of TPN reduction, with concomitant ATP formation, observed in the cell-free photochemical system approach 80% of the maximum rate of photosynthesis recorded for the intact leaf.

In higher plants the respiratory pigment haemoglobin has been detected only in root nodules of leguminous plants. It occurs only when nodulation is initiated by an active nitrogen-fixing strain of the endophytic symbiont *Rhizobium*. It is now known that a number of non-legumes bearing nodules on their roots are capable of high rates of nitrogen fixation and that the nodules have a high haematin content. Although previous attempts to demonstrate haemoglobin in these non-legume nodules had given negative results, a re-examination was suggested by Bond's finding that carbon monoxide inhibits nitrogen fixation in these plants. Through the generous co-operation of Dr. G. Bond of the Department of Botany, Glasgow University, it was possible to make a spectroscopic examination of the pigments in nodulated material from *Alnus*, *Myrica*, *Hippophae* and *Casuarina*. In *Casuarina* nodules a pigment having the spectroscopic characteristics of oxyhaemoglobin was found to account for 75% of the total haematin present. This pigment possesses the essential property of a respiratory carrier—the capacity to

undergo reversible oxygenation—and forms a compound with carbon monoxide. Unlike the haemoglobin of legume nodules the *Casuarina* haemoglobin is not easily extracted into solution and oxidation to methaemoglobin occurs rapidly when the nodules are disrupted. Evidence was obtained that similar haemoglobins occur in *Alnus* and *Myrica*. An account of this work has been submitted for publication.

Plant Constituents.

The phenolic compounds of the leaf of the quince rootstock have been examined. Quince leaf lacks any distinctive phenolic such as phloridzin in apple leaf or arbutin in pear leaf; in other respects it resembles pear leaf rather than apple leaf, containing both chlorogenic and isochlorogenic acids in appreciable amount. The flavonol glycosides show an unusual picture. Derivatives of both kaempferol and quercetin are present but those of kaempferol are relatively much more important than in the apple or pear leaf; both types appear to be present mainly as diglycosides containing the sugars rhamnose and galactose.

As previously reported, apple bark contains phloridzin in quantity and small amounts of an arabinoglucoside of phloretin. Further study of the other phenolics has shown the presence of glycosides of quercetin and kaempferol similar to those found in apple leaf; in addition a glucoside of the flavanone eriodictyol, and a rhamnoglucoside of a so far unidentified flavonol have been found.

Chromatograms of leaf and bark extracts of different apple species show variations in the relative amounts of the various flavonol glycosides, and some of the patterns are sufficiently distinctive to be of use in checking the identity of doubtful species against authentic samples. Since the flavonol glycosides are of almost universal occurrence in leaves, such a method would be potentially of very wide application. It is being tried out on the collections of *Ribes* and *Salix* species available at Long Ashton.

As was shown several years ago, the distinctive phenolic patterns of the parent material are maintained on either side of a pear scion—quince rootstock union. With the discovery of other dihydrochalkone derivatives in various *Malus* species, a larger number of distinctive phenolic marker compounds is available, and combinations of appropriate species have been used to demonstrate the lack of movement of these substances across unions between different *Malus* species. Further experiments on unions between apple, pear, quince and sorbus are in progress: in no case has a distinctive phenolic occurring naturally on only one side of a union been found to cross it.

The observation made at East Malling that chlorogenic acid can move within an apple shoot when introduced into the vascular system through a cut petiole has been confirmed; arbutin shows a similar mobility, and will even move across a graft union after being taken in through the roots of a maiden apple tree. On the other hand no evidence has been obtained for the uptake and movement of phloridzin and other dihydrochalkones into a pear shoot or tree by either of these routes. It would thus appear that phenolic substances differ in their mobility within the vascular system, and that even those, such as arbutin, which can move may not be able to enter the vascular system from the site of their formation within the cell.

THE A.R.C. UNIT OF PLANT NUTRITION (MICRO-NUTRIENTS).

By T. WALLACE, Honorary Director.

Whilst the main events relating to the formation and development of the Unit and the scientific activities of its members have been recorded in the Station Annual Reports from 1942 to the present time, it is thought that a brief account, outlining the events that led to its formation and summarizing its subsequent history, will be of interest to those readers who have been specially interested in the work, and will also serve as a convenient and co-ordinated record of events.

The work carried out by the Unit was, in essence, a natural expansion of the investigations on the nutrition of fruit trees that had been begun by the Director of the Unit in 1920. The obvious long-term nature of such investigations had led him to adopt the sand culture method as a rapid means of obtaining data which might be applied to field problems. This led to the development of methods of visual diagnosis and plant analysis, which by 1939 had been widely used to solve many nutritional problems of fruit crops in commercial orchards.

On the outbreak of war in 1939, the Minister of Agriculture invited Professor Wallace to act as adviser to the Ministry on nutritional problems of horticultural crops, and following this the Agricultural Research Council and the Ministry of Agriculture collaborated in schemes to harness the efforts of research station staffs to the food production campaign. To this end the Agricultural Research Council later set up a committee, under the chairmanship of Sir Edward Salisbury, to co-ordinate the work on plant nutrition at a number of research institutes.

As a result, Long Ashton workers became actively concerned in advisory problems covering the whole range of agricultural and horticultural crops. As the visual diagnosis method had been a special feature of the Long Ashton work, and as fruit crops were not regarded as of special importance in the war effort, it was decided to apply the sand culture techniques to problems of farm crops and vegetables, and to use some of the fruit manurial plots at Long Ashton for nutritional investigations on vegetables grown in rotation.

Concurrently with these developments, Professor Wallace, in collaboration with the Advisory Chemists' Conference of the Ministry of Agriculture, laid down a number of indicator plots with farm crops, in areas where the soils provided special problems, on which the methods of visual diagnosis and plant analysis were tested as rapid methods of determining the nutrient status of a wide variety of crops. Meanwhile the intensified food production and ploughing-up campaigns had thrown up many new and puzzling problems of crop failures, which were investigated by the Long Ashton team, then consisting of Professor Wallace, Mr. J. O. Jones and Dr. D. A. Osmond. Chief among these problems were severe potassium deficiency in cereal and root crops on chalk soils and on newly ploughed-up grass areas ; magnesium deficiency in tomatoes, Brassica crops, potatoes and oats ; calcium deficiency in potatoes on strongly acid soils ; boron deficiency in many root crops (especially sugar beet) and Brassicas ; and manganese deficiency in cereals, peas, root crops,

Brassicas and potatoes. Many of these problems were new even in the experience of farmers and growers of long standing ; their occurrence was often associated with special districts and soil conditions, and with certain crops.

Among the problems that call for comment and record, and were subjects of important and urgent investigations by the Long Ashton team, were the following :

The failure of cereal crops from manganese deficiency on newly ploughed-up rich alluvial soils, and on calcareous clays and peats, and on limed black podsolic soils ; outstanding examples occurred on the rich pasture soils around Bridgwater, the Lias clay and Coal Measure areas to the north of Bristol, Fen soils in East Anglia and the East Midlands, and acid podsols in the West Midlands.

Boron deficiency in sugar beet was severe in all sugar beet areas on a wide range of soils, particularly on chalk soils and the light-textured soils of the West Midlands.

Magnesium deficiency of tomatoes was prevalent in most glasshouses and presented difficult problems, both in control methods and supplies of magnesium salts.

Potassium deficiency problems were acute and difficult to remedy on large areas of chalk soils, and on many ploughed-up old grasslands ; the large extension of the potato area to new districts in the Midlands and the West greatly increased the occurrence of the deficiency, as also did the Dig for Victory Campaign for increasing food production in allotments and gardens.

The hill pasture improvement scheme in Montgomeryshire and the ploughing-up of common lands in the Midlands produced novel problems in the potato crop, viz. widespread failures from soil acidity, in which the main causal factors were shown to be deficiencies of calcium and magnesium, both of which were readily diagnosed by the visual method and remedied by the use of dressings of suitable ground limestone materials.

The progress made in the early stages in dealing with problems such as these was spectacular and attracted the attention of both the farming community and the Agricultural Research Council. One result of the latter was a two-day visit in the summer of 1942 of Dr. W. W. C. Topley and Mr. E. H. E. Havelock of the Agricultural Research Council and Mr. H. Biggs of H.M. Treasury, to inspect field problems and experimental plots in Wiltshire and areas around Bristol, and the pot experiments at Long Ashton. As an immediate result the Research Station was asked to organize a three-day demonstration of the work in progress at Long Ashton and in the Bristol area, to which were invited representatives of County Agricultural Executive Committees and their agricultural staffs in the Bristol Advisory Province, and officers of the Ministry of Agriculture and of the Fertilizer Control. Following these events the Station was invited by the Agricultural Research Council to submit proposals for the extension of the work, and the research team was increased by the appointment of E. J. Hewitt, D. J. D. Nicholas and W. Plant.

The enlarged staff made possible considerable extension of the various branches of the work. Dr. Hewitt greatly expanded the scope and extent of the pot experiments, especially in the fields of micro-nutrients, the effects of toxic metals and the examination of injurious factors of the soil acidity complex. An outcome of these investigations was the publication by Dr. Hewitt in 1952 of a book entitled "Sand and Water Culture Methods used in the Study

of Plant Nutrition" (Commonwealth Agricultural Bureaux). Dr. Nicholas specialized in the development of quick chemical tissue tests, in conjunction with J. O. Jones and W. Plant in the initial stages, and in the *Aspergillus niger* method for the estimation of macro- and micro-nutrients in plants and soils. As a result, these methods were soon added to the routine diagnostic procedures. Mr. J. O. Jones, along with Dr. Plant and Dr. Nicholas, shared the responsibility for the field experiments and later Dr. Plant became the recognized field officer, both for field trials and crop surveys and for liaison with Advisory Chemists and County staffs.

During the whole of this period very close collaboration was maintained with Advisory Chemists, particularly W. Morley Davies, West Midlands, H. T. Cranfield, East Midlands, F. Hanley, Cambridge, N. H. Pizer, Wye College area, N. M. Nicholson, Reading, and A. W. Ling, Bristol Province.

In 1943, at the suggestion of the Agricultural Research Council, the 1st edition of the Colour Atlas of Mineral Deficiencies by Professor Wallace was published by H.M.S.O., to which a Supplement was added in 1944. The special object in publishing the Atlas at this time was to help Advisory Officers and farmers to recognize some of the novel problems presented by the greatly intensified and expanded cropping programmes and to deal with them speedily and effectively. The book also contained a description of the various methods of diagnosis used by the Long Ashton team, which were especially designed for rapid diagnosis to supplement the traditional methods of soil analysis.

By 1945, when most of the major field problems had been recognized and control methods evolved, attention became focused on more fundamental aspects of the practical wartime problems, and gradually new lines of work were evolved. Two special problems also received attention at this stage, that of molybdenum deficiency in crops and the Swayback condition in lambs, associated with defective copper metabolism ; in the latter instance the special interest of the team was to determine whether or not " Swayback soils " were intrinsically deficient in copper for crop production. It was shown in the experiments that the soils supplied adequate copper even to highly susceptible crops.

In 1951 the second edition of the Colour Atlas in a greatly expanded form was published to meet a wide demand both at home and abroad, a reprint becoming necessary in 1957.

In developing the post-war programme some additions to the senior staff were made, to permit a very comprehensive scheme of fundamental investigations to be undertaken. Following these developments the team was formally constituted a Unit of the Agricultural Research Council from 1st April 1952.

Shortly after the formation of the Unit the Director was invited by The British Council to organize a course of lectures at Long Ashton for overseas students on the subject of Mineral Disorders in Plants with Special Reference to Trace Elements. The course, comprising a series of lectures and demonstrations given in July 1952 by members of the Unit Staff, attracted seventeen graduate students, several of them experienced research workers, from nine countries.

In the final post-war re-organization of work, Dr. Hewitt has continued to develop sand and water culture methods and to adapt them for large-scale work and specialized purposes, including sterile-culture techniques. His main investigations, however, have comprised detailed biochemical, morphological

and histological studies of the functions of trace elements and of phosphorus in higher crop plants. So far his work has centred chiefly around molybdenum in relation to the problem of Whiptail in cauliflower.

Mr. A. J. Abbott is studying methods of plant tissue culture as a basis for examining the functions of trace elements in the growth of tissues and cells.

Dr. Nicholas has specialized in problems of the mineral nutrition of micro-organisms, and in particular has followed the roles of trace elements in the enzyme systems concerned in the reduction systems, nitrate→ nitrite→ hyponitrite→ hydroxylamine→ ammonia. More recently he has begun investigations on nitrogen fixation by soil organisms such as *Azotobacter* and *Clostridium*.

Mr. A. H. Williams was appointed in 1947 to investigate some of the major groups of organic compounds in plants, as a basis for studying the effects of trace element deficiencies on metabolic activities. His attention has been chiefly given to amino acids and polyphenols ; the results obtained have already proved of great scientific interest and will have many applications to work in other sections of the Research Station.

In 1956 the biochemical work of the Unit was extended by the appointment of Dr. H. E. Davenport, who had previously specialized in the biochemistry of iron compounds. His work at Long Ashton has been concerned with the effect of trace elements, so far of iron and manganese, on chlorophyll and haem pigments.

To help in understanding the role of trace elements in plant enzyme systems, Dr. H. M. Stevens studied the valency changes of trace metals concerned in enzyme actions in plant tissues, and was able to establish the nature of the valency change in the molybdenum of nitrate reductase when nitrate is reduced to nitrite by this enzyme. He also studied chelating systems of trace metals as a basis to studies of the chemical actions affecting the availability of metallic nutrients in soils.

In 1949 studies on the metabolism of various inorganic compounds in soil were begun at Long Ashton by Dr. H. Gleen, who had previously worked on this subject under Professor J. H. Quastel. After his retirement from Long Ashton in 1953 due to ill health, his work was continued by Dr. R. A. Webb, who had been transferred from service in The Gambia to the Unit in 1953. Dr. Webb extended this field of study to include the effect of chemical and biological factors on the availability of trace elements in soils.

It will be seen that this post-war organization of the Unit enabled a very comprehensive attack to be made on important fundamental problems concerned with the role of micro-nutrients in the nutritional processes of higher crop plants and micro-organisms, and it is to be expected that the various studies will yield results of scientific interest and importance of a similar order to those achieved in more practical fields by the members of the Unit under wartime conditions.

The Unit, as such, was disbanded on 30th September 1959, following the retirement of the Director, in accordance with the normal practice of the Agricultural Research Council for Units whose work has centred around the special researches developed by their Directors. The work, however, will be continued by members of the team working in various sections of the Research Station in conjunction with colleagues with similar interests and engaged on related problems.

APOMICTIC SEEDLING ROOTSTOCKS FOR APPLES: PROGRESS REPORT II.

By A. I. CAMPBELL.

The nursery performance of trees of Cox's Orange Pippin, Lord Lambourne and Worcester Pearmain on seedling rootstocks of three apomictic *Malus* species, compared with their performance on two clonal rootstocks, has been described in a previous report (1). Two of these species, *M. sikkimensis* and *M. toringoides*, proved satisfactory in the nursery; measurements of growth and a study of the root structure suggested that both would prove to be at least as vigorous as M.II.

Trees from this nursery trial were planted out in 1956 to compare the vigour, cropping and uniformity of Cox, Worcester and Lambourne on *M. sikkimensis*, *M. toringoides* and M.II. In 1955 further nursery trials with these two apomictic rootstocks and with M.II and M.XVI were made with a wider range of dessert and culinary apples.

Orchard Trial.

Lay-out.

Seventy-two trees from the nursery trial were planted out during March, 1956, when they were three years old; they consisted of eight replicates of each combination of the varieties Cox, Worcester and Lambourne with the rootstocks *M. sikkimensis*, *M. toringoides* and M.II. They were arranged in four blocks containing two trees of each combination. The varieties were planted in rows (E–W) and the rootstocks in double rows (N–S). Guard trees of Cox's Orange Pippin on *M. sikkimensis* and *M. toringoides* were planted along the north boundary of the plot and unworked trees of *M. sikkimensis* and *M. toringoides* for seed production along the east side.

The trees were spaced 12 ft. × 10 ft. in heavy sand overlying silty clay, with slightly impeded drainage. The plot was cultivated during the summer months of the first four years; wild white clover was sown at 2 lb. per acre in July, 1959.

Trees on all rootstocks, except Cox on *M. toringoides*, had begun to crop in the nursery; the mean crop in ounces per tree during the second and third years was as follows:

	Cox's Orange Pippin	Worcester Pearmain	Lord Lambourne
M. sikkimensis	7·0	11·5	10·5
M.II	9·0	9·0	13·5
M. toringoides	—	7·0	8·0

After planting in the orchard the trees were deblossomed during the first year and drastically thinned to one fruit per cluster in the second season. Winter pruning has been light and has followed the renewal system. The trees have a 2′ 9″ leg and have been trained to form a delayed open centre. Plate I shows the appearance of the seven-year-old trees at the end of 1959.

Records.

Records have been taken annually of the diameter of the main stem 10″ above the union, and of the quality, size, weight and storing properties of the crop. Observations on anchorage, suckering and resistance to pests and diseases have also been made.

Results.

Fig. 1 shows the average annual growth increase for all the combinations from 1955-1959. It can be seen that there is a marked interaction between rootstock and variety and that, unlike clonal rootstocks, the apomictic stocks cannot be classified as generally dwarfing or vigorous without reference to the scion variety. For instance, Cox on *M. toringoides* is more vigorous than on M.II, whereas Lord Lambourne on *M. toringoides* is more dwarfed than on M.II. It can be seen in Plate I that trees on the apomictic rootstocks are more spreading than those on M.II ; this applies particularly to Cox and Lambourne.

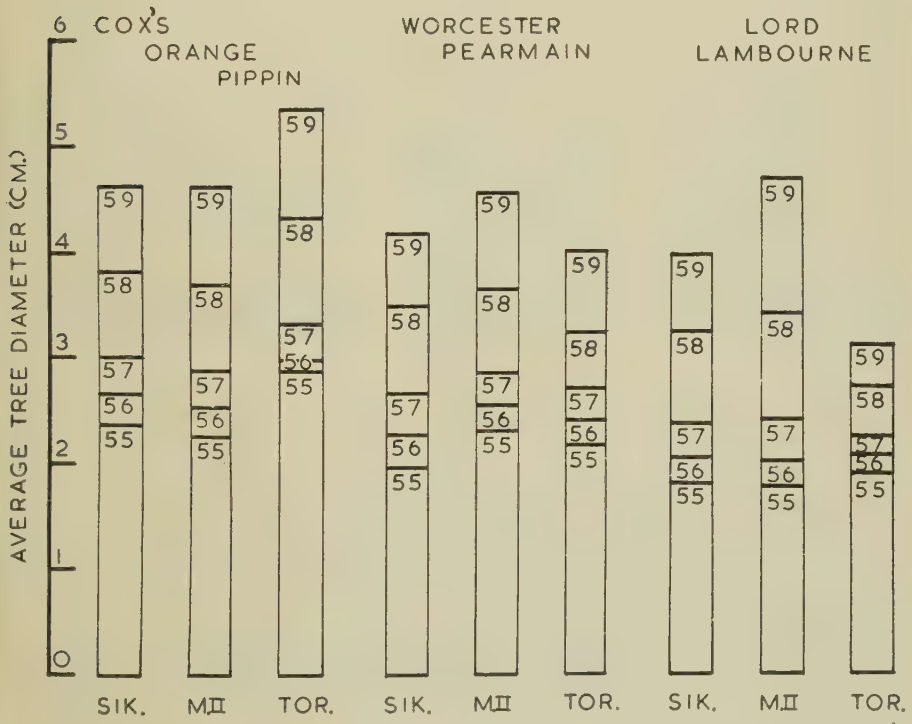

Fig. 1. Average diameters (cm.) of scion/rootstock combinations annually from 1955 (3 years old) to 1959.

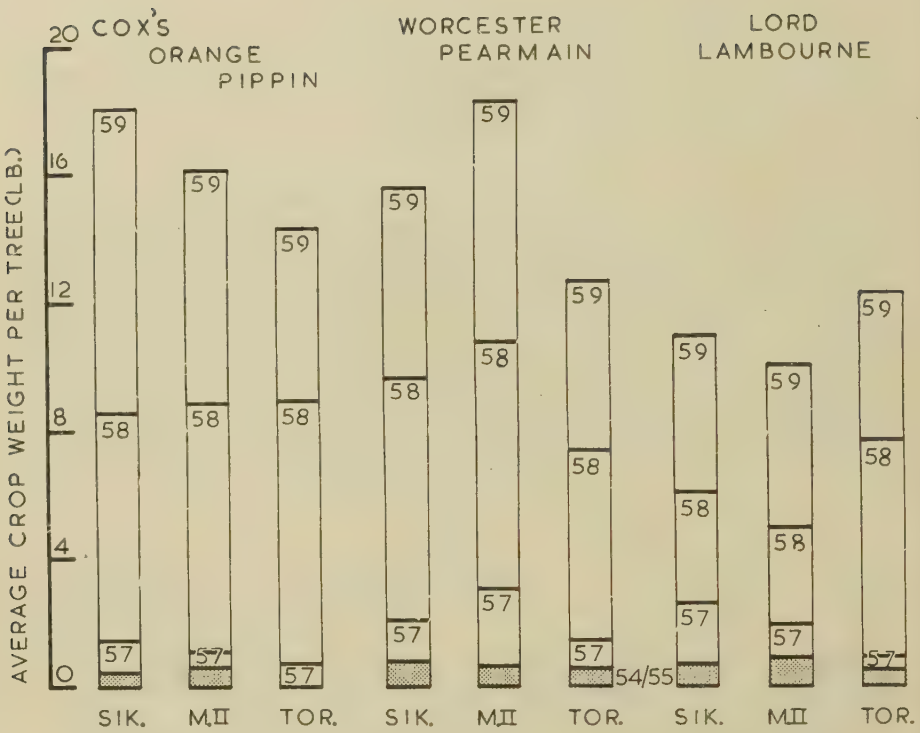

Fig. 2. Average annual and cumulative crop weight (lb.) per tree in nursery (1954/55 shaded) and orchard (1957-59).

Fig. 2 shows the average annual crop weight from each combination, including that harvested while the trees were in the nursery. The results so far obtained are summarized below.

Malus toringoides. Cox's Orange Pippin on *M. toringoides* has grown strongly. A slight check after transplanting reduced growth for a season, but after four years in the orchard the trees are considerably larger than those on M.II and *M. sikkimensis* (Fig. 1 and Plate I). Crop weights have been less than those from trees on the other two rootstocks and the individual fruit size has been smaller ; the apples have ripened later and colour has been good. This is the only combination that did not fruit during the time the trees were in the nursery. These facts suggest that Cox will make a vigorous or very vigorous tree on *M. toringoides.*

Worcester Pearmain on *M. toringoides* is weaker than on M.II and about the same size as on *M. sikkimensis.* The crop has been less than that from both the other rootstocks. Fruit size, colour and keeping quality have been similar on all rootstocks.

Lord Lambourne is considerably weaker on *M. toringoides* than on M.II but crop weights have been heavier and the fruit has matured earlier than that from trees on M.II and *M. sikkimensis.* It seems probable that Lord Lambourne on *M. toringoides* will make an early cropping dwarf or semi-dwarf tree.

PLATE I.

Seven-year-old trees of Cox, Worcester and Lambourne on clonal and apomictic seedling rootstocks.

Cox's Orange Pippin
on
M. sikkimensis

Worcester Pearmain
on
M. sikkimensis

Lord Lambourne
on
M. sikkimensis

Cox's Orange Pippin
on
M.II

Worcester Pearmain
on
M.II

Lord Lambourne
on
M.II

Cox's Orange Pippin
on
M. toringoides

Worcester Pearmain
on
M. toringoides

Lord Lambourne
on
M. toringoides

PLATE II.

Root systems of three-year-old Lord Lambourne on *Malus sikkimensis* and M.II.

Lord Lambourne on *Malus sikkimensis*.

Lord Lambourne on Malling II.

Malus sikkimensis. Cox's Orange Pippin on *M. sikkimensis* has grown at about the same rate as the trees on M.II, but the average yield per tree has been 11% higher. The fruit has also been slightly larger and better coloured than that from trees on M.II.

Worcester Pearmain has made a smaller tree on *M. sikkimensis* than on M.II and the crop weight has been 14% less.

Lord Lambourne on *M. sikkimensis* is more vigorous than on *M. toringoides* but both stocks are more dwarfing than M.II. The crop from the two apomictic rootstocks has, however, been heavier and better coloured, and has ripened earlier than that from M.II.

It is difficult to be certain of the vigour grouping of such young trees, but it would appear to be as follows :

	Cox's Orange Pippin	Worcester Pearmain	Lord Lambourne
M. sikkimensis	Vigorous	Semi-dwarfing	Semi-dwarfing
M.II	Vigorous	Vigorous	Vigorous
M. toringoides	Very vigorous	Semi-dwarfing	Dwarfing

The trees on the seedling rootstocks appear to be well anchored and have shown no tendency to sucker. Some of them have been killed by apple canker (*Nectria galligena*) which has attacked the main stem and crotch ; trees on *M. toringoides* have suffered most severely : seven out of twenty-four have had to be replaced, compared with three on M.II and one on *M. sikkimensis*. The comparatively vigorous Cox's Orange Pippin suffered most on *M. toringoides* : four trees were replaced compared with two of Lord Lambourne and one of Worcester Pearmain.

Nursery Trial.

In the spring of 1955 seedlings of *M. sikkimensis* and *M. toringoides* were planted for comparison with M.II and M.XVI in four blocks each containing 160 rootstocks. In every block there were four sub-plots containing ten stocks of each type. Each sub-plot was budded during the summer of 1955 with one of the four varieties : Bramley's Seedling, Cox's Orange Pippin, Lord Lambourne and Worcester Pearmain.

A similar but smaller experiment tested another range of dessert and culinary varieties on the same four rootstocks. Ten trees of each of the varieties listed in Table II were budded on ten of each type of rootstock. All the varieties grew well with the exception of Sunset, with which the bud-take on all four rootstocks was poor and all the buds on *M. toringoides* died. The heights and diameters of the maiden trees are shown in Tables I and II. It will be seen that all the varieties make vigorous nursery trees on the apomictic rootstocks. The effect of rootstock on the variety is not as regular as that of clonal rootstocks, e.g. while Lane's Prince Albert is stronger on *M. sikkimensis* than on *M. toringoides* the reverse is true of Beauty of Bath. The results in Table I are very similar to those obtained with the same varieties and rootstocks in the first nursery trial (1).

The variability in the height of the maiden trees is expressed as percentage coefficient of variation in Table III. It can be seen that the trees on *M. sikkimensis* and *M. toringoides* in this experiment are less variable than those on M.XVI when worked with Cox and Lambourne, but are more variable when worked with Bramley and Worcester. Trees on M.II are less variable than those on either apomictic rootstock.

TABLE I.

MEAN HEIGHT (CM.) AND DIAMETER (MM.) OF ONE-YEAR-OLD TREES.

(Originally 40 trees of each combination).

Rootstock	Cox		Worcester		Lambourne		Bramley	
	Height	Diam.	Height	Diam.	Height	Diam.	Height	Diam.
M. sikkimensis	95	10	72	8	69	8	86	12
M. toringoides	104	10	88	10	83	8	94	12
M.II	90	10	74	10	67	8	62	11
M.XVI	76	10	78	10	88	10	85	12

TABLE II.

MEAN HEIGHT (CM.) AND DIAMETER (MM.) OF ONE-YEAR-OLD TREES.

(Originally 10 trees of each combination).

	Lane's Prince Albert		Laxton's Superb		Merton Prolific	
Rootstock	Height	Diam.	Height	Diam.	Height	Diam.
M. sikkimensis	130	9	114	9	89	10
M. toringoides	112	8	107	9	82	9
M.II	101	9	111	10	78	10
M.XVI	117	9	129	11	76	10
	Laxton's Fortune		Beauty of Bath		Sunset	
Rootstock	Height	Diam.	Height	Diam.	Height	Diam.
M. sikkimensis	64	7	82	8	59	7
M. toringoides	98	7	104	9	—	—
M.II	58	7	99	11	52	7
M.XVI	88	7	92	8	41	7

TABLE III.

PERCENTAGE COEFFICIENT OF VARIATION IN HEIGHT OF ONE-YEAR-OLD TREES.

(Originally 40 trees of each combination).

	Cox's Orange Pippin	Worcester Pearmain	Lord Lambourne	Bramley's Seedling
M. sikkimensis	6·0 (± *2·1*)	8·2 (± *2·9*)	15·7 (± *5·6*)	9·2 (± *8·3*)
M. toringoides	10·9 (± *3·9*)	13·7 (± *4·8*)	18·4 (± *6·5*)	5·8 (± *2·1*)
M.II	5·6 (± *2·0*)	4·0 (± *1·4*)	9·7 (± *3·4*)	3·8 (± *1·3*)
M.XVI	12·6 (± *4·5*)	7·6 (± *2·7*)	23·4 (± *8·3*)	2·9 (± *1·0*)

Two 3-year-old trees of Lord Lambourne on *M. sikkimensis* and M.II were lifted to compare the types of root system. It can be seen from Plate II that *M. sikkimensis* seedlings worked with Lambourne produce a more fibrous root system with fewer deep-penetrating roots than M.II.

Two pear varieties, Conference and Williams' Bon Chrétien were also tested on the two apomictic rootstocks and on M.II and M.XVI. Both varieties made 30–40 cm. of growth on all rootstocks ; the union between rootstock and scion was, however, very brittle, and all the trees died during the first dormant season after showing typical symptoms of incompatibility.

Discussion.

The results obtained from these seven-year-old trees suggest that varieties will react differently with the apomictic rootstocks, so that it may not be possible to forecast their vigour. This behaviour is less common but not unknown with clonal rootstocks, with which Hatton (2) has shown certain scion varieties to behave unexpectedly.

The three dessert varieties Cox, Worcester and Lambourne have not grown as anticipated on either *M. sikkimensis* or *M. toringoides* : both rootstocks have produced less vigorous and earlier cropping trees than their nursery growth and root structure had suggested. A final assessment of potential vigour and cropping will not be possible for some years, but it seems likely that Cox on *M. sikkimensis* will make a heavy-cropping medium-sized tree which may compare favourably with trees on M.II. Cox on *M. toringoides* will probably be more comparable with trees on M.XXV, and produce a very vigorous but early cropping tree.

Worcester Pearmain has been disappointing on both apomictic stocks : although precocious neither has carried as heavy crops as trees on M.II.

M. sikkimensis and *M. toringoides* may be particularly useful rootstocks for Lord Lambourne, if a semi-dwarf or dwarf tree is required ; their freedom from virus is an important consideration in raising trees of a variety so susceptible to virus infection.

The comparatively heavy casualties from apple canker suffered by some of the stock/scion combinations may have been accentuated by the poor drainage of the plot and the heavy rainfall at Long Ashton. The delay in grassing down, due to the lack of vigour in some stock/scion combinations, may have adversely affected some of the stronger ones.

Further nursery trials have confirmed that both *M. sikkimensis* and *M. toringoides* make vigorous nursery trees when worked with a wide range of dessert and culinary apples. The variation usually associated with seedling rootstocks is only slight with apomictic seedlings ; some varieties are in fact less variable than on M.XVI. The trees come into cropping as soon as those on M.II, usually during the second year in the nursery, and much sooner than trees on crab or free seedling stocks. Transplanting from the nursery has interrupted the cropping for a relatively short time, probably because of the very fibrous root system.

To obtain further information on the value of *M. sikkimensis* and *M. toringoides* as rootstocks it is planned to carry out more extensive field trials in which they will be compared with some of the more recent Malling and Malling-Merton rootstocks.

Summary.

An account is given of the comparative performance of seven-year-old trees of Cox's Orange Pippin, Worcester Pearmain and Lord Lambourne on apomictic seedlings of *Malus sikkimensis*, *Malus toringoides* and on M.II during three years in the nursery and four years in the orchard.

Cox has made a vigorous tree on *M. sikkimensis* and a very vigorous tree on *M. toringoides* : it has fruited early on both rootstocks and the total crop from trees on *M. sikkimensis* has been heavier than that from trees on M.II.

Worcester and Lambourne have made dwarf or semi-dwart trees on the apomictic rootstocks. Crops from Lambourne on *M. sikkimensis* and *M. toringoides* have been heavier than those on M.II, whereas crops from Worcester have been lighter.

Nursery trials have shown that a wide range of varieties make vigorous trees on *M. sikkimensis* and *M. toringoides* that are as uniform as those on some clonal rootstocks.

Acknowledgments.

For their advice and help I am indebted to Dr. L. C. Luckwill, who instigated this study, and to Mr. E. W. Hobbis and Dr. D. Wilson. I have received valued assistance from Mr. J. S. Coles and Miss Margaret Shellard and from members of the photographic and statistical sections.

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A NOTE ON FRUIT SET AND FRUIT DROP IN RELATION TO POSITION ON THE TRUSS IN THE APPLE VARIETY LAXTON'S SUPERB.

By BARBARA A. RAKE.

It is well-known that the terminal blossom in an apple truss possesses different characteristics from the lateral flowers (1). Visser (2) has examined the characteristics of blossoms of a number of varieties with regard to their position on the truss. A knowledge of the fruit set of blossoms in relation to their time of opening and their position on the truss may be helpful in the timing of fruit-thinning sprays, for the materials at present available require to be applied as soon after full bloom as possible.

An account is given of experiments made with the apple variety Laxton's Superb to determine the relation between the position of the blossom on the truss, its size and final set of fruit.

Experimental.

36 potted trees of Laxton's Superb were brought into an unheated greenhouse at the first signs of bud burst, during the third week of February. Blossoming took place between March 22nd and 27th. As each blossom opened it was pollinated with Cox pollen ; no blossom could have dropped through lack of pollination.

Individual blossoms on 150 trusses were labelled according to their position. The truss consists of a terminal blossom with 3–6 others arranged spirally below it at intervals of 2/5 ; the lowest three blossoms occur in leaf axils. The terminal blossom was designated I ; the one immediately below it II, and so on downwards. Of the 150 trusses selected for observation 12 had four blossoms and 15 had seven ; the rest had either five or six. The first drop, of atrophied blossoms, occurred between April 2nd and 8th. There was no first drop of partially developed fruitlets. The equivalent of a June drop took place between April 28th and May 8th.

Records were made of the date of opening, diameter of corolla when fully expanded, blossom and fruit drop, final fruit-set, seed content and weight of fruit.

Results.

Order of opening.

In every case the terminal blossom on the truss expanded first and blossom II always expanded last. The remaining blossoms expanded simultaneously within a period of 1–3 days (depending on conditions) between the opening of I and II.

Size of flowers.

This varied between 3 and 5 cm. There appeared to be no relation between size of flower and position on the truss. Nor was there a relation between size of flower and fruit set except for blossoms in the terminal position, where those of 5·0 cm. diameter gave a significantly ($P=0{\cdot}01$) higher set than those of 3·5 cm. diameter (Table I).

TABLE I.

FINAL FRUIT SET IN RELATION TO POSITION ON THE TRUSS AND SIZE OF FLOWER.

Diam. of flower (cm.)	3·0		3·5		4·0		4·5		5·0	
Position	Number Total	Set	Number Total	Set	Number Total	Set	Number Total	Set	Number Total	Set
I	7	5	40	26	62	52	16	12	25	23
II	39	1	44	1	56	1	10	0	1	0
III	15	0	51	1	50	4	27	1	7	0
IV	6	1	43	4	67	7	27	5	7	1
V	4	0	39	1	73	3	19	0	3	0
VI	4	0	13	0	38	5	7	1	1	0
VII	1	0	2	0	10	0	1	0	1	0
Totals	76	7	232	33	356	72	107	19	45	24
Percentage set	9·2		14·2		20·0		17·8		53·5	

TABLE II.

FRUIT DROP, FRUIT SET, WEIGHT AND SEED CONTENT IN RELATION TO POSITION ON THE TRUSS.

Position	I	II	III	IV	V	VI	VII
Number of blossoms	150	150	150	150	138	63	15
Drop; atrophied (%)	0	91	47	21	31	21	40
June drop (%)	21	7	49	67	66	70	60
Final set (%)	79	2	4	12	3	9	0
Mean weight fruit (kg.)	0·34	0·10	0·13	0·22	0·30	0·35	—
Mean seed content	5	6	8	9	8	9	—

Drop of atrophied blossoms.

Blossom II, although the last to expand, was nearly always the first to drop off after petal fall; in fact nearly all the blossoms in this position on the truss came off at this stage. (Table II).

No terminal blossoms dropped at this time; their advantage in development is no doubt due to their position on the truss and their advanced stage of growth in relation to other blossoms on the truss.

About half the blossoms in position III dropped at this stage and a third of those in each of the other positions.

June drop and final set.

21% of the terminal blossoms dropped during the June drop, leaving 79% final set. The rate of June drop of the blossoms in the other positions was inversely proportional to the first drop. The final set of blossoms in positions III, V, VII was no better than that of those in position II. (Table II)

Fruit size and seed number.

The terminal fruit and those in positions V and VI were the largest. (Table II). It is possible that those in the lower positions gain in foodstuffs from the subtended leaf what they lose from their disadvantageous position on the truss.

The terminal fruits had the lowest number of seeds, and those fruits in position II which reached maturity also had a low number. It appeared that the fruits in the lower positions were stimulated to increased growth by the larger number of seeds which they contained.

Acknowledgment.

I am grateful to Mr. G. M. Clarke and Miss M. Holgate for the statistical analysis of the data.

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THE EFFECT OF GIBBERELLIC ACID ON FRUIT SET IN APPLES AND PEARS.

By L. C. LUCKWILL.

Introduction.

Although synthetic auxins are effective in inducing parthenocarpy in tomatoes and certain other fruits, their use for this purpose in apples and pears has met with very limited success. Gorter and Visser (2), for instance, recently reported that of 21 varieties of apple and a similar number of pears tested by them for their ability to produce mature parthenocarpic fruits in the absence of pollination, only one apple variety (Laxton's Superb) showed any response to auxin applications.

The general failure of synthetic auxins to stimulate parthenocarpy in the pome fruits has led to the challenging of the widely accepted hypothesis that hormones of this type are always the limiting factors in the setting and subsequent growth of fruits (6). Studies of the endogenous auxins of the apple (5) and the fig (1) have also cast doubt on the validity of this hypothesis and have served to focus attention on the possible rôle of other types of hormone in fruit setting. Amongst these the gibberellins are of particular interest; for not only have the young seeds of a number of species been found to be rich sources of endogenous gibberellins, but gibberellic acid (GA) itself has recently been shown capable of inducing parthenocarpy in a number of species (e.g. *Rosa arvensis* Huds.) that do not respond to auxin treatment (4). It was therefore considered of interest to study the effect of GA on fruit set in apples and pears and, in particular, its ability to stimulate parthenocarpic development of fruits from flowers in which pollination had been prevented. The possibility of a synergistic action between GA and auxin, such as has been reported for a number of other growth phenomena, was also investigated.

Experimental.

This was essentially a pilot trial designed to give a preliminary assessment of the effect of auxin and GA, applied separately and together, on a range of varieties. The experiments were carried out on dwarf pyramid trees of the six varieties of apple and two varieties of pear listed in Table I. The pears, on Quince A stocks, were eight years old ; the apples, on M.II, were from six to eight years old.

Pollination was prevented by cutting off the styles with a pair of fine pointed scissors as each blossom reached the " balloon " stage ; this was done over a period of several days. At petal fall all unopened blossoms were removed and whole trees were sprayed with the potassium salt of GA, the auxin α-(2-naphthoxy)-propionic acid (2-NOP), or with a mixture of the two. 2-NOP was chosen as an auxin known to cause little damage to vegetative growth and one that has occasionally proved effective in stimulating parthenocarpy in pears (7). The effect of GA on fruit set of open-pollinated flowers was also investigated. The following is a summary of the treatments applied and their code letters :—

O	=	Pollination prevented ; no treatment. Control.
OG	=	Pollination prevented ; sprayed with GA 50 p.p.m.
OA	=	Pollination prevented ; sprayed with 2-NOP 50 p.p.m.
OAG	=	Pollination prevented ; sprayed with 2-NOP 50 p.p.m.+GA 50 p.p.m.
P	=	Open-pollinated control.
PG	=	Open-pollinated ; sprayed with GA 50 p.p.m. at petal-fall.

The number of trees per treatment varied from one to ten, depending on the number of blossom clusters per tree. Estimates of initial set were made 13 to 25 days after full bloom by counting the number of fruitlets that showed clearly visible swelling, and expressing this as a percentage of the number of blossoms. Estimates of final set were made in mid-July (Table I). The effect of the treatments on the initial swelling of the fruitlets was also investigated by measuring the diameters of a sample of 25 fruitlets, 11 to 18 days after full bloom, before the first drop had started (Table II) ; these measurements were made on all varieties except Rosemary Russet, in which the drop started before records could be obtained.

Results.

Effect on initial set of unpollinated flowers.

In five of the eight varieties a small percentage of flowers whose styles had been cut (Treatment O) showed some swelling of the ovary, and in three of these (Miller's Seedling, Rosemary Russet and WRL/28) a few mature parthenocarpic fruits were produced (Table I).

Six varieties responded to the GA spray (Treatment OG) with an increased initial set and, of these, three (Miller's Seedling, Sturmer Pippin and Williams' Pear) showed a similar though less marked response to 2-NOP (Treatment OA). Lord Lambourne was unusual in responding to the auxin spray but not to GA, while Cox responded to neither treatment. Only in Sturmer Pippin was there a suggestion that the combined spray of 2-NOP + GA was more effective in stimulating fruit set than either compound applied singly.

TABLE I.

FRUIT-SET OF APPLES AND PEARS AS INFLUENCED BY SPRAYS OF GIBBERELLIC ACID (G) AND α-(2-NAPHTHOXY)-PROPIONIC ACID (A) AT PETAL-FALL.

Variety	*	Days after bloom	Treatment O	OG	OA	OAG	P	PG
Lord Lambourne	n	—	569	585	539	711	663	741
	i	21	11	8	22	3	41	22
	f	78	0	0	0	0	5	2
Cox's Orange Pippin	n	—	270	522	471	225	215	470
	i	18	0	0	1	0	15	6
	f	73	0	0	0	0	4	1
Seedling WRL/28	n	—	154	250	180	247	385	347
	i	13	7	13	3	15	56	51
	f	67	1	0	0	1	6	9
Miller's Seedling	n	—	368	311	435	290	286	258
	i	22	7	49	15	47	70	66
	f	78	3	8	5	9	39	27
Sturmer Pippin	n	—	197	264	255	208	218	—
	i	18	3	36	22	66	53	—
	f	73	0	0	0	0	8	—
Rosemary Russet	n	—	351	422	266	279	293	343
	i	16	4	9	3	18	19	17
	f	70	1	0	0	0	10	6
Laxton's Superb Pear	n	—	485	533	537	639	849	567
	i	25	0	24	0	15	24	20
	f	78	0	10	0	8	8	8
Williams' B.C. Pear	n	—	389	404	552	379	588	382
	i	25	0	53	31	45	31	30
	f	78	0	8	3	5	6	6

*n = number of blossoms treated ; i = initial set ; f = final set as % number of blossoms. For treatments *see* p. 60.

TABLE II.

MEAN DIAMETER OF 25 FRUITLETS IN MM. ; MEASURED BEFORE THE FIRST DROP.

Variety	Days after bloom	Treatment O	OG	OA	OAG	P	PG
Lord Lambourne	17	4·9*	5·2*	*7·2**	4·5*	*8·1*	*8·6*
Cox's O.P.	11	3·7*	3·8*	3·8*	3·7*	*7·1*	*7·0*
Seedling WRL/28	13	3·9*	*5·0**	3·9*	*5·5**	*9·4*	*8·2**
Miller's Seedling	18	4·3*	*6·7**	*5·1**	*6·2**	*7·9*	*7·1**
Sturmer Pippin	16	4·1*	*8·6**	*8·0**	*8·5**	*9·6*	—
Laxton's Superb Pear	18	3·6*	*5·4**	4·1*	*5·6**	*6·0*	*5·7*
Williams' B.C. Pear	18	4·1*	*6·8**	*6·7**	*6·4**	*7·9*	*7·1**

*Values are significantly less, at the 5% level, than the pollinated controls (P). Values in italics are significantly greater, at the 5% level, than the unpollinated controls (O). For treatments *see* p. 60.

With the exception of Sturmer Pippin and the two pear varieties the set of unpollinated flowers induced by the sprays was less than the natural set resulting from open pollination (Treatment P), and the diameter of the parthenocarpic fruitlets was always significantly less than that of the normal seeded ones (Table II). The smaller diameter of the GA-induced fruitlets, however, was partly attributable to their more elongated shape, particularly in the pears. (Plate III, Fig. 1).

Production of mature parthenocarpic fruit.

In five of the eight varieties, all the parthenocarpic fruitlets produced as a result of treatment with GA or 2-NOP fell before they were half-grown, but mature parthenocarpic fruits were produced on Miller's Seedling apple and both varieties of pear. The GA-induced set on the pears was particularly striking, and in both varieties was somewhat greater than the natural set of the open-pollinated trees (Table I). The mean fruit weights given in Table III are of necessity based on rather small numbers, but they show that there was comparatively little difference in weight between the parthenocarpic and seeded fruits. There were, however, very marked differences in shape, the GA-induced fruits being more elongated than either the seeded or the auxin-induced fruits. In the pears this elongation seemed to result from an abnormal development of the calyx end of the fruit and was accompanied by a characteristic puckering around the eye (Plate IV, Fig. 2). No differences in flavour or time of maturity were noted. In the pear variety Laxton's Superb the GA treatments resulted in the retention of a rather large number of partially developed chats, which failed to abscis in the June drop ; these were disregarded in estimating fruit set and fruit weight.

TABLE III.

MEAN WEIGHT (G.) OF PARTHENOCARPIC AND SEEDED FRUITS AT HARVEST.

Treatment	Apple Miller's Seedling	Pear Laxton's Superb	Pear Williams' B.C.
P	67 ± 2·1	103 ± 2·2	133 ± 5·3
PG	71 ± 2·7	102 ± 3·8	131 ± 4·6
OG	70 ± 3·3	91 ± 3·3	111 ± 5·9
OA	77 ± 6·0	—	125 ± 4·1
OAG	66 ± 2·9	105 ± 3·2	115 ± 5·5

Effect of GA on fruit set of open-pollinated flowers.

It will be noticed from Table I that GA applied at petal-fall to open-pollinated trees produced a marked diminution in fruit set in three of the seven varieties tested (Lambourne, Cox, Miller's Seedling) ; on the remaining varieties the effect was small or non-existent. The reason for this thinning effect of GA is not known. GA had no observable effect on the size or shape of the open-pollinated apples, but on both pear varieties it induced abnormalities of the type illustrated in Fig. 2.

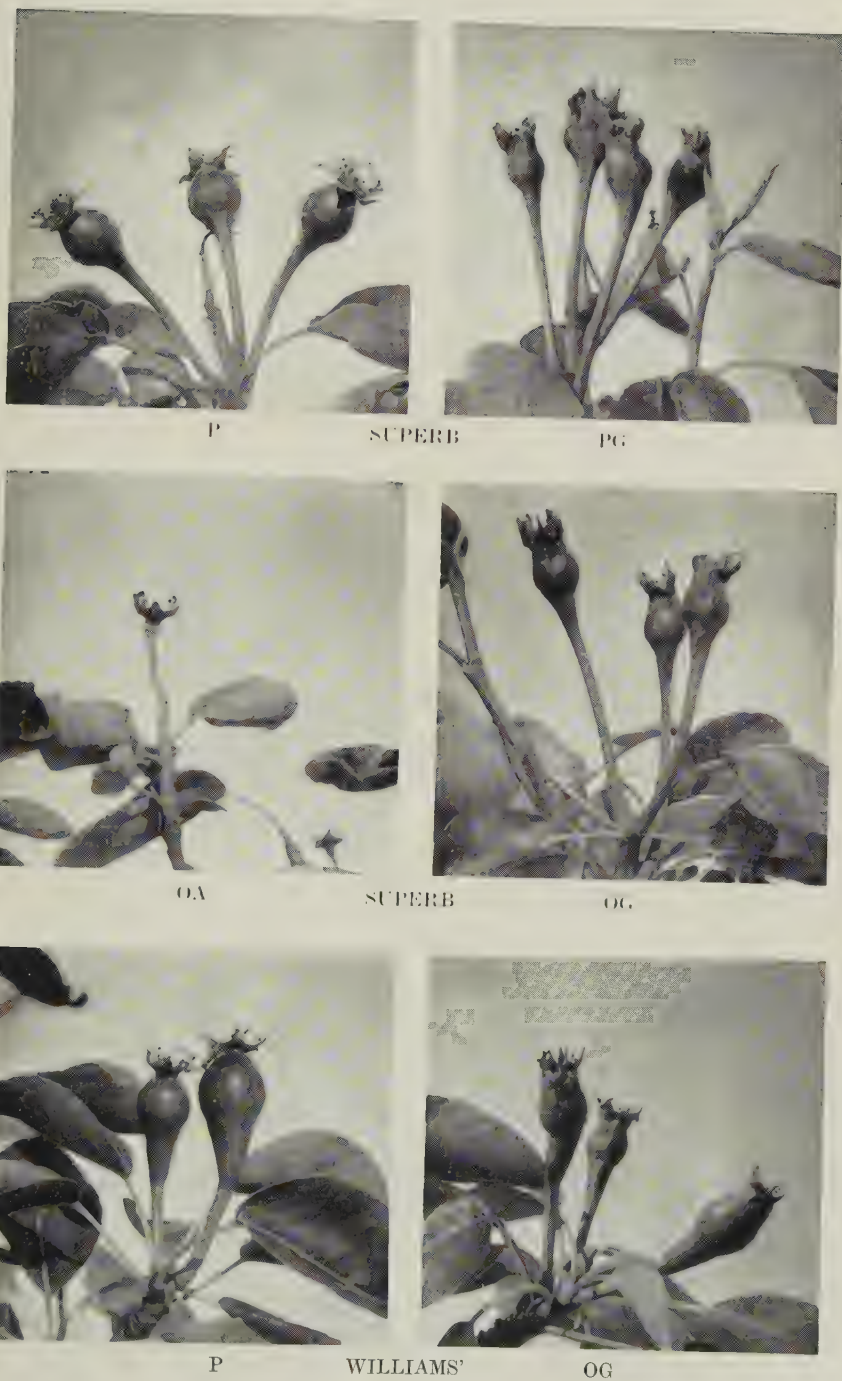

Fig. 1. Typical fruitlet clusters of the pear varieties Laxton's Superb and Williams' Bon Chrétien, 18 days after full bloom. P = pollinated ; O = pollination prevented ; G = sprayed with GA 50 p.p.m. ; A = sprayed with 2-NOP 50 p.p.m. (*See* p. 60).

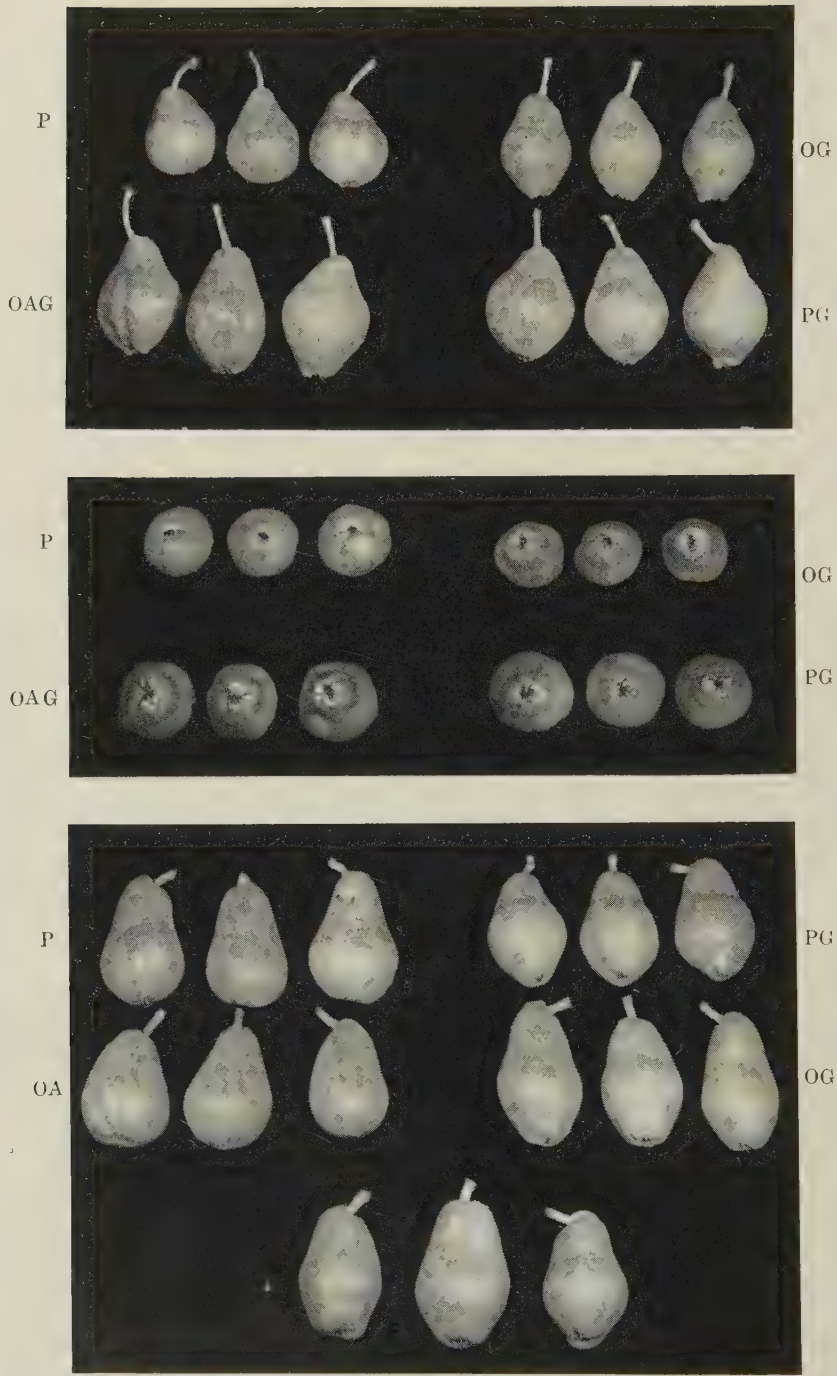

Fig. 2. *Top* : Fruits of Laxton's Superb resulting from treatment with GA and 2-NOP.
Middle : End view of Laxton's Superb pears showing abnormal eye structure of fruits treated with GA.
Bottom : Fruits of Williams' resulting from treatment with GA and 2-NOP. (*See* p. 60).

No effects of either GA or 2-NOP on the vegetative growth of the trees were observed in these experiments.

Discussion.

The chief interest of this experiment lies in the demonstration that GA is capable of stimulating the early growth of the fruit in both apples and pears and that, in most varieties, it is more active than the auxin 2-NOP used at the same concentration. In pears the stimulus from a single application of GA at petal-fall was comparable with that normally resulting from pollination and seed development, and resulted in the production of a full crop of parthenocarpic pears. In apples the stimulus from GA, as measured by initial set and rate of swelling of the fruitlets, was less strong, and in all varieties except Miller's Seedling it was insufficient to hold the fruits on through the June drop. It is, however, possible that a higher initial concentration or repeated applications might have proved more effective.

These results with apples and pears are comparable with those obtained by Jackson and Prosser for roses (3, 4). These authors found that parthenocarpy could readily be induced in *R. rugosa* with α-naphthalene acetic acid and other auxins : *R. spinosissima* responded weakly to auxins, more strongly to GA, and most strongly to a mixture of GA and auxin (cf. Sturmer Pippin in the present experiment) : *R. arvensis* showed no response to auxins but developed parthenocarpic fruits following treatment with GA (cf. Laxton's Superb pear).

The general conclusion to be drawn from these experiments would seem to be that both auxins and gibberellins may be involved as hormonal factors in fruit setting and that sometimes one and sometimes the other may be the limiting factor. However, the failure of Cox's Orange Pippin to respond to either type of substance raises the question whether a third, as yet unknown, factor may not also be involved.

From the practical point of view the significance of these experiments lies in the possibilities that they offer for the development of sprays that will ensure the development of a full crop of fruit from frost-damaged flowers.

Summary.

(1) Aqueous solutions of the potassium salt of gibberellic acid (GA) and α-(2-naphthoxy)-propionic acid (2-NOP), both at 50 p.p.m., were sprayed at petal-fall on dwarf pyramid trees of six varieties of apple and two varieties of pear.

(2) On trees where pollination had been prevented by cutting off the styles, GA stimulated the early swelling of the fruitlets and increased initial set, though only in the apple Miller's Seedling and the pears Laxton's Superb and Williams' were mature parthenocarpic fruits produced. Four varieties showed an initial response to 2-NOP, and in one of these (Williams' pear), mature parthenocarpic fruits were obtained.

(3) GA applied at petal-fall to open-pollinated trees usually resulted in some diminution of fruit-set in apples.

(4) Parthenocarpic pears produced by GA treatment were slightly smaller than seeded fruits and of abnormal shape.

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GROWTH SUBSTANCES AS FRUIT-THINNING AGENTS FOR APPLES: PROGRESS REPORT.

By D. L. ABBOTT.

Introduction.

In a previous article in this series (1), an experiment was described in which 1-naphthalene-acetamide (NAm), applied to the variety Crawley Beauty in 1955, increased the marketable crop in that year and also caused an increase in blossom, with a consequent increase in marketable crop, in the following year. It seemed possible that had the same branches been sprayed again in 1956 and succeeding years, larger crops of marketable fruit might have been harvested for an indefinite period.

A trial to determine the effect of repeating sprays in successive years was started in 1957 and is reported below.

Experimental.

Twenty branches, as uniform as possible in size and amount of blossom, were selected, two from each of ten mature trees of Crawley Beauty. The same ten branches were sprayed with NAm in 1957, 1958 and 1959 while the remaining ten were left unsprayed as controls. The NAm, formulated as a wettable powder, was applied as an aqueous suspension at a concentration of 25 p.p.m. two days after petal-fall. The weather was warm and sunny in 1957 and warm but overcast in 1958 and 1959 at the time of spraying. The number of blossom clusters on each branch was recorded every spring and, at harvest, the fruit was weighed and graded by size. The branches were not pruned during the experiment.

Results and Discussion.

The results are shown in Fig. 1. The effect of spraying in 1957 has been to reduce very considerably the number of small fruits and to increase slightly the number of large fruits. As in the previous trial, an increase in the amount

of blossom was obtained on the sprayed branches in the year following the initial application of NAm. In spite of this increased blossom, however, the thinning effect of a second application of NAm was such as to reduce the total crop again in 1958, though the reduction was entirely in the number of small fruits, and the number of large fruits was increased. Thus the effect of spraying for the first two years was not only an increase in the proportion of large fruits, but a gain in the absolute number of large fruits.

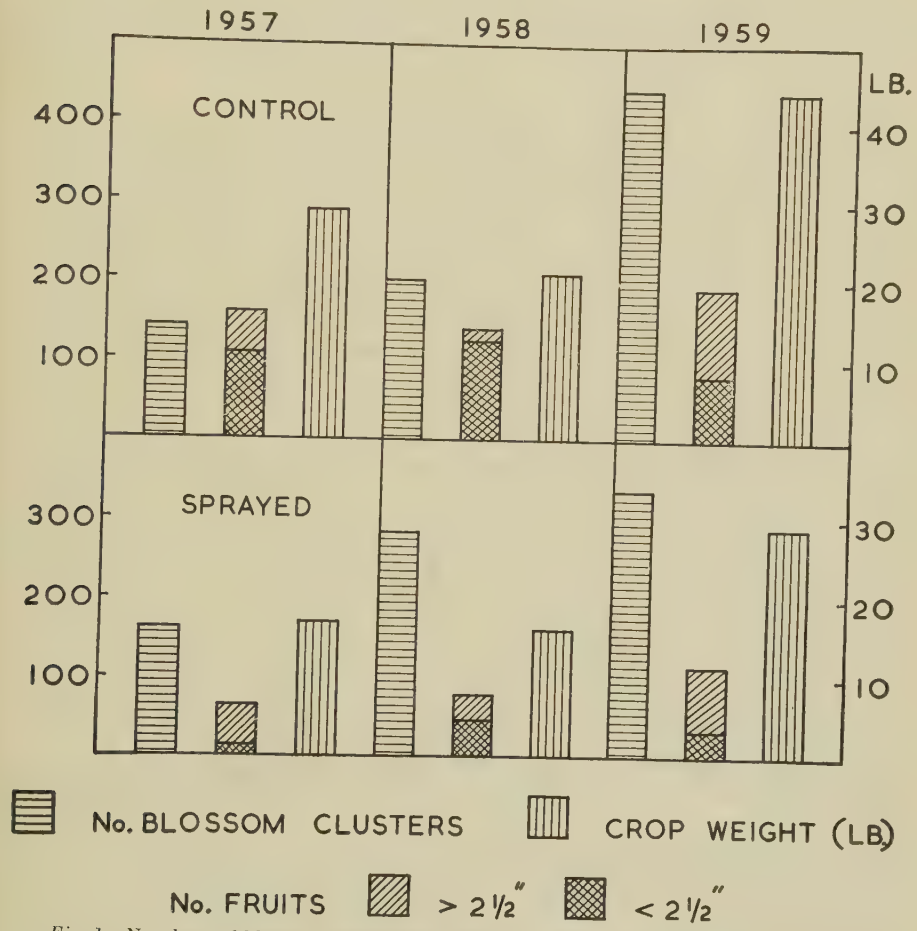

Fig. 1. Numbers of blossom clusters and fruits, and weight of crop from sprayed branches and unsprayed controls.

Since no pruning was done on the experimental branches, a gradual increase in the amount of blossom would be expected during the three years, because of additional growth. In 1959, however, the control branches blossomed with exceptional profusion—this may have been due to the relatively light crop in 1958 (21 lb./branch) or to environmental conditions conducive to fruit bud formation—but no such corresponding increase in blossom was obtained on the sprayed branches. Although the amount of blossom on these

branches was greater in 1959 than in 1958, it was smaller than that on the controls. The control branches carried a good crop of well-sized fruits, and the thinning effect of the NAm treatment was to reduce not only the amount of small fruit but, to a lesser extent, the amount of large fruit. Since the 1959 crop was large compared with that of the previous two years, this result negatived the previous beneficial effect of spraying.

The cumulative crop for the three years was as follows :

	Control	*Sprayed*
Blossom clusters	786	782
Fruits $< 2\frac{1}{2}''$	317	94
Fruits $> 2\frac{1}{2}''$	174	163
Crop weight (lb.)	94	62

It will be seen that while the total number of blossom clusters and large fruits $>2\frac{1}{2}''$ was not affected by treatment with NAm, the number of small fruits was reduced by approximately two-thirds and the total crop weight by one-third. It must be emphasized, however, that the dividing line between small and large fruits was arbitrarily taken as $2\frac{1}{2}''$. Also, although there was no difference between the number of fruits $>2\frac{1}{2}''$ from the sprayed and control branches, the mean size of those from the sprayed branches was larger than that of the fruits from control branches ; any financial gain due to the greater weight of these fruits would probably have been offset, however, by the value of the extra fruits $<2\frac{1}{2}''$ on the control branches.

Continued spraying in successive years would appear to have been no more successful than previous single-year trials. Indeed, prolonged treatment may be detrimental, for over the period of this trial the gain by spraying, as reflected in the increase in mean weight of treated fruits over control fruits, was 1·3, 0·9 and 0·3 oz. per fruit in 1957, 1958 and 1959 respectively. This decline, together with an overall loss of one-third in total crop weight and no apparent commensurate increase in vegetative growth, suggests that the treated branches are " running down " and that eventually the size of fruits from sprayed branches may be smaller than that of the control fruits.

The crop obtained from an orchard varies considerably from year to year, both in total yield and in the size of individual fruits, even from a variety such as Crawley Beauty which is regarded as a regular cropper (Fig. 1). In a year such as 1959, when there is abundant blossom and sufficient self thinning to produce a large crop of good sized fruits, treatment with NAm is likely to be of negative value. On the contrary, in a year such as 1958, when almost the entire crop is of sub-optimal size, treatment is likely to be beneficial, for any increase in the number of large fruits will be of value, and the reduction in the number of small fruits will save time and expense in harvesting. In 1957 the proportion of large to small fruit was intermediate between that of the other two years, and in this circumstance the use of NAm is of doubtful value.

The extent to which a thinning spray might benefit a grower would have to be assessed by local economic considerations such as the relative values of fruit of different grades and the availability of labour for picking. It seems, however, that the ultimate success of NAm as a fruit thinning agent will depend upon the more accurate determination of the conditions under which thinning is required, and the ability to recognize or forecast these conditions early in the growing season.

Summary.

(1) 1-naphthaleneacetamide was applied at 25 p.p.m. to the same branches of Crawley Beauty in the three consecutive years 1957-59.

(2) Treatment resulted in fruit thinning each year, but only in 1958 was a significant increase in the number of large fruits ($>2\frac{1}{2}''$) obtained.

Acknowledgments.

Thanks are due to the American Chemical Paint Company for the gift of the naphthaleneacetamide, and to Mr. G. M. Clarke for statistical analysis of the results.

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A SURVEY OF PERRY PEARS IN THE WEST MIDLANDS: III. NORTH GLOUCESTERSHIRE.

By GILLIAN NORTH-SMITH.

The survey of the perry-growing areas of the West Midlands was extended in 1959 to north Gloucestershire. The distribution of perry pears in north-west and south-west Gloucestershire had already been examined (1, 2) and this account completes the survey of the main perry-growing districts of the county, with the exception of the Royal Dean Forest area. The parishes covered by this survey are shown in Fig. 1.

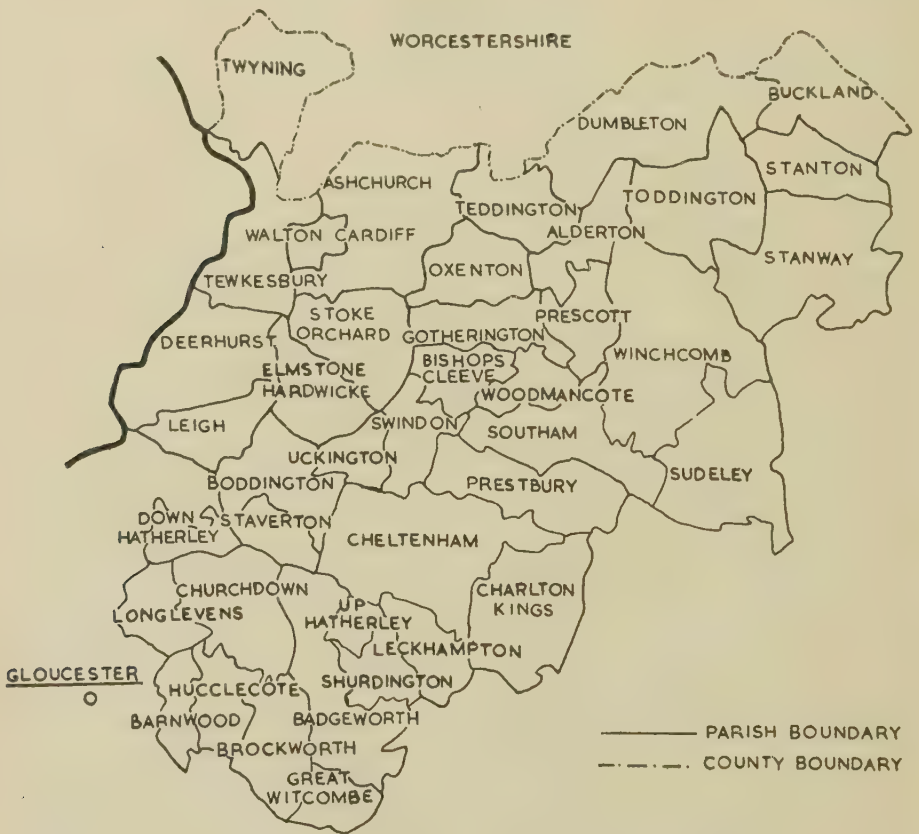

Fig. 1. A Parish Map of North Gloucestershire.

The commonest varieties were Barland, Butt, Oldfield and Malvern Hills, all of which have been found widely distributed throughout the county. Several good varieties not previously recorded were found in north Gloucestershire, among them Jenkins Red and Teddington Green, which are notable for their common occurrence in some parishes. Some varieties recorded in previous surveys were found in this area but had no recognized name in some districts; these included a few common varieties such as New Meadow and Rock. Only a few new synonyms were obtained for the varieties previously recorded.

Names, Synonyms and Distribution.

As in the previous surveys the distribution shown is that of the name and not the variety. The preferred name of each variety is followed by a list of synonyms, the names in square brackets being those preferred in the first two surveys (1, 2). Varieties illustrated in the works of Knight (3), Hogg & Bull (4, 5), Durham (6), Williams (7, 8, 9) and Williams & North-Smith (10) are indicated respectively by the letters K, H & B, D, W7, W8, W9, and W10 placed after the varietal name.

[Arlingham Squash] .. H & B, D, W9. *Distr.* : Ashchurch, variety uncommon.
Barland .. .. .. K, H & B, D, W7. *Distr.* : all parishes, common.
Blacksmith .. .. *Distr.* : Teddington, uncommon.
Blakeney Red .. .. H & B, D, W7. *Distr.* : Badgeworth, Leckhampton, Down Hatherley, Boddington, Elmstone Hardwicke, Winchcomb, Twyning, Ashchurch, uncommon.
Blunt Red .. .. *See* Red Pear. *Distr.* : Deerhurst, uncommon.
Brown Bess .. .. W10. *Distr.* : Churchdown, Deerhurst, uncommon.
Butt .. .. .. H & B, D, W7. *Syn.* : Norton Butt. *Distr.* : all parishes, common.
Choke Dog .. .. *Distr.* : Oxenton, uncommon ; general term for perry pears.
Ducksbarn .. .. *Distr.* : Great Witcombe, Badgeworth, Deerhurst, Tewkesbury, frequent.
Early Longdon .. .. *Distr.* : Gotherington, uncommon.
Garradine .. .. *Distr.* : Oxenton, uncommon.
Golden Balls .. .. *Distr.* : Winchcomb, uncommon.
Goldings .. .. *Distr.* : Teddington, uncommon.
[Green Longdon] .. W8. *Distr.* : Badgeworth, variety uncommon.
Hampton Rough .. *Distr.* : Teddington, uncommon.
Hartpury Green .. *Distr.* : Shurdington, uncommon.
Hatherley Squash .. *Distr.* : Up Hatherley, uncommon.
Hedge Hog Pear .. W7. *Distr.* : Winchcomb, uncommon.
[Barnet]
[Holmer] .. .. H & B, D, W8. *Distr.* : Shurdington, variety uncommon.
Honey Knob .. .. *Distr.* : Teddington, uncommon.
Huffcap .. .. .. K, H & B, D, W7. *Distr.* : many parishes, common.
[Yellow Huffcap]
Iron Sides .. .. *Distr.* : Teddington, uncommon.
Jenkins Red .. .. *Distr.* : Badgeworth, Staverton, Cheltenham, Uckington, Teddington, frequent.
Jug Rumbles .. *See* Rumblers.
Longdon .. .. *See* Red Longdon.
Lullam .. .. .. D. *Distr.* : Great Witcombe, uncommon ; old general purpose variety.
Malvern Hills .. .. H & B, D, W7. *Distr.* : all parishes, common.
[Moorcroft]
Newbridge .. .. W10. *Distr.* : Deerhurst, uncommon ; this variety is called White Moorcroft in North West Glos. (1).
New Meadow .. .. H & B, D, W8. Name uncommon ; variety common in parishes adjoining the Worcestershire border.
Norton Butt .. .. *See* Butt. *Distr.* : parishes near the Severn.
Oldfield .. .. .. K, H & B, D, W7. *Distr.* : all parishes, common.
Pig Pear .. .. *Distr.* : Elmstone Hardwicke, Deerhurst, uncommon.
Pine .. .. .. W9. *Distr.* : Badgeworth, uncommon.
[Pint]
Red Horse .. .. *See* Red Longdon.
Red Longdon .. .. K, H & B, D, W7. *Syn.* : Longdon. *Distr.* : all parishes, common ; often confused with Red Horse (1) in parishes bordering Worcestershire.
Red Pear .. .. H & B, D, W7. *Syn.* : Blunt Red. *Distr.* : Ashchurch, common.
Rock .. .. .. H & B, D, W7. Name uncommon ; variety found in many parishes.
Rumblers .. .. *Syn.* : Jug Rumbles, Rumble Jumble. *Distr.* : Elmstone Hardwicke, uncommon.
Rumble Jumble .. *See* Rumblers.
Snake Pole .. .. *Distr.* : Oxenton, uncommon ; very old culinary variety.
Squash Pear .. .. *Distr.* : many parishes ; general name for early harvesting perry pears.

Swan Egg	*Distr.* : Badgeworth, Brockworth, Shurdington, Winchcomb, Ashchurch ; name used for many general purpose pears that are elliptical in shape.
Taynton Squash ..	*Distr.* : Gotherington, uncommon ; also another variety, *Distr.* : Prescott, uncommon ; neither of these varieties is the same as the Taynton Squash (H & B, W7) distributed by Long Ashton 1909-1920.
Teddington Green ..	*Syn.* : Teddingtons. *Distr.* : Woodmancote, Bishops Cleeve, Gotherington, Teddington, common.
Teddingtons	*See* Teddington Green.
Thorn	H & B, D, W8. *Distr.* : Teddington, Winchcomb, Southam, Stoke Orchard, Gotherington, uncommon.
[Turners Barn]	W.8 *Distr.* : Woodmancote, variety uncommon.

Acknowledgments.

The author wishes to thank all the farmers and perry makers whose assistance has made this survey possible ; also Mr. R. R. Williams for his help and advice.

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PERRY PEARS AND THEIR CHARACTERS: IV.

By R. R. WILLIAMS and GILLIAN NORTH-SMITH.

In three previous articles (1, 2, 3), thirty-seven varieties of perry pear found in the West Midlands were described. The present paper continues the series with descriptions and illustrations of a further nine varieties of perry pears from Gloucestershire and Herefordshire.

The figures given with each description contain drawings of typical fruits in longitudinal section, together with a flattened spur leaf. The typical winter appearance of mature trees is illustrated by photographs.

Brown Bess.

SYN. BROWN BESSIE.

Fruit: 44–70 mm. long, 43–66 mm. diameter. Shape turbinate. Stalk 11–24 mm.; sometimes connected to fruit by fleshy lip. Stem basin absent or absent to slight. Eye basin slight or well defined. Calyx slightly open or upright. Sepals free, sometimes fleshy at base, usually pubescent; stamens usually attached well below base of sepals. Skin green or yellowish green, flush absent; russet complete or nearly so; lenticels numerous, often conspicuous; scab absent. Core has axial sac, filled; seeds brown or black. Flesh has stone cells below eye and weak ring around core. Taste juicy, flavour slight, acid; astringency absent or slight; possesses a slight aroma. Harvest 2nd–4th week October. Milling period up to 3 weeks after harvesting. Cropping heavy.

Tree: Medium to large. Many narrow-angled crotches, usually several upright limbs; numerous branches, horizontal or drooping due to crops.

Flower: Flowering period mid-season. Flower buds white. Styles longer than stamens. Pollen germination very poor.

Leaf: Stalk 15–40 mm. Blade 29–65 mm. long, 27–39 mm. wide; elliptical, tip acute, sometimes acuminate, base rounded, inclined to tapering; serrations present, often slight; slightly wavy margin to leaf blade.

General notes: Common in south Gloucestershire. Originally used as a culinary variety.

Flakey Bark.

Fruit: 43–60 mm. long, 38–52 mm. diameter. Shape turbinate or pyriform. Stalk 16–36 mm., usually connected to fruit by fleshy lip. Stem basin absent, sometimes slight. Eye basin wide and shallow, often well defined. Calyx upright, sometimes strongly reflexed. Sepals touching or joined; stamens attached at base of sepals. Skin pale green or yellowish green, flush absent or rare, diffuse, reddish brown; russet spreading, sometimes complete; lenticels large, brown, conspicuous; scab absent or trace. Core has axial sac, sometimes well defined, sometimes filled; seeds black, often few. Flesh has stone cells below eye and pronounced ring of stone cells around core, stone cells large. Taste, some juice, acid, very astringent; possesses little aroma. Harvest 2nd–4th week October. Milling period up to 3 weeks after harvesting. Cropping moderate.

Tree : Medium to large. Wide-angled crotches, straggling limbs. Bark on main limbs easily flakes off in patches.

Flower : Flowering season late mid-season. Flower buds have slight flush. Styles longer than stamens. Petals have pink blotches.

Leaf : Stalk 15–37 mm. Blade 49–72 mm. long, 31–41 mm. wide ; elliptical or ovate, tip acute, base rounded, inclined to cordate ; serrations present, slight.

General notes : An uncommon variety found in the vicinity of Newent and noted for its astringency. Trees can be identified by the patchy off-white colour of the limbs and trunk and the absence of a thick corky bark.

Gregg's Pit.

Fruit : 43–65 mm. long, 38–55 mm. diameter. Shape turbinate, sometimes pyriform. Stalk 14–28 mm., usually connected to fruit by fleshy lip. Stem basin absent, stem often merging with fruit. Eye basin well defined, rarely slight, wide and deep. Calyx stiff, upright, often broken. Sepals touching or free, rarely joined ; stamens attached at base of sepals. Skin pale green, flush variable, usually absent or slight ; russet round stem and eye, often spreading to cheek ; lenticels russeted, fairly conspicuous ; scab usually present. Core has axial sac which is usually well defined ; seeds black, a large proportion usually flattened. Flesh has fairly heavy concentration of stone cells below eye, and around core. Taste juicy, usually astringent ; possesses a slight aroma. Harvest 1st–2nd week October. Milling period up to 1 week after harvesting. Cropping fairly good.

Tree : Large. Acute-angled crotches ; usually a small number of large, long upright limbs with small lateral branches.

Flower : Flowering season mid-season. Flower buds white. Styles considerably longer than stamens.

Leaf : Stalk 38–69 mm. Blade 49–70 mm. long, 42–50 mm. wide ; elliptical, tip acuminate, base rounded, inclined to tapering ; serrations pronounced.

General notes : A common variety in the vicinity of Much Marcle.

Merrylegs.

Fruit : 34–44 mm. long, 33–48 mm. diameter. Shape turbinate or pyriform, rarely oblate. Stalk 10–20 mm., sometimes connected to fruit by fleshy lip. Stem basin absent. Eye basin absent or very slight. Calyx upright, stiff and prominent. Sepals touching, rarely free, fleshy at base ; stamens attached at base of sepals. Skin pale green ; flush present, usually heavy ; russet spreading to cheek ; lenticels numerous, small light brown ; scab absent. Core has axial sac well defined, seeds black. Flesh has prominent concentration of stone cells around core. Taste sweet, slightly astringent ; pronounced pear flavour and aroma. Harvest 1st–2nd week October. Milling period up to one week after harvesting. Cropping irregular.

Tree : Medium to small. Narrow-angled crotches. Numerous long spreading limbs terminating in thick twiggy branches.

Flower : Flowering period mid-season. Flower buds slightly pink. Very little pubescence on inflorescence.

Leaf : Stalk 28–53 mm. Blade 48–68 mm. long, 41–53 mm. wide ; elliptical, tip acute, base cordate ; serrations present, often strongly pronounced.

General notes : A variety found on the eastern edge of the Royal Forest of Dean.

Nailer.

Fruit : 30–48 mm. long, 32–47 mm. diameter. Shape turbinate, sometimes pyriform. Stalk 9–38 mm., sometimes connected to fruit by fleshy lip. Stem basin absent, sometimes very slight. Eye basin slight, wide and shallow. Calyx slightly open or upright. Sepals joined ; stamens attached at base of sepals. Skin greenish yellow ; flush slight, sometimes heavy ; russet spreading to cheek ; lenticels very small, brown ; scab absent or very slight. Core has axial sac, sometimes filled ; seeds black. Flesh has a slight concentration of stone cells below eye. Taste acid, astringent ; very slight aroma. Harvest after November 1st. Milling period over three weeks. Cropping slight to medium, regular.

Tree : Small. Narrow-angled crotches. Trunk usually continued as centre leader. Few large limbs ; numerous branches of twiggy growth.

Flower : Flowering period mid-season. Flower buds slightly pink.

Leaf : Stalk 30–58 mm. Blade 43–53 mm. long, 33–45 mm. wide ; elliptical inclined to ovate, tip acuminate or obtuse, base rounded ; serrations present, often slight.

General notes : A common variety in the vicinity of Newent. The fruits are difficult to dislodge from the tree and may hang onwell into next year ; hence the name Nailer.

Newbridge.

SYN. WHITE MOORCROFT.

Fruit : 40–56 mm. long, 42–60 mm. diameter. Shape turbinate rarely oblate. Stalk 17–40 mm., often connected to fruit by a fleshy lip, sometimes green. Stem basin absent or very shallow, sometimes merging. Eye basin shallow. Calyx strongly reflexed, large and star-shaped. Sepals usually joined ; stamens attached at base of sepals. Skin greenish yellow or yellow ; flush rare ; russet around stem and eye, sometimes spreading to cheek ; lenticels small, brown, conspicuous ; scab absent or slight. Core has axial sac which is large and usually well defined ; seeds black. Flesh has slight concentration of stone cells below eye and some cells round core. Taste juicy, pronounced pear flavour, slightly astringent ; strong aroma. Harvest 1st–3rd week October. Milling period up to one week after harvesting. Cropping heavy.

Tree : Large. Several very large upright limbs, usually wide-angled crotches at base with characteristic bends where upright growth recommences. Branches rather sparse and brittle. Extension shoots usually curved, often horizontal or pendulous.

Flower : Flowering period mid-season. Flower buds pink. Flowers large, petals slightly pink, stamens bright red.

Leaf : Stalk 35–56 mm. Blade 53–66 mm. long, 41–49 mm. wide ; elliptical inclined to ovate, tip obtuse or acuminate, base cordate, sometimes rounded ; serrations pronounced.

General notes : Probably triploid.

Parsonage.

Fruit : 38–50 mm. long, 31–50 mm. diameter. Shape turbinate or pyriform, rarely elliptical. Stalk 18–36 mm. ; usually green, often connected to fruit by fleshy lip. Stem basin absent, sometimes slight. Eye basin absent, sometimes very slight. Calyx upright. Sepals joined, rarely touching ; stamens attached just below base of sepals. Skin pale green ; flush absent ; russet dense around eye spreading to cheek ; lenticels fairly conspicuous, brown ; scab often present. Core has axial sac which is often filled ; seeds black. Flesh has a prominent concentration of stone cells below eye and a few around core. Taste juicy, fairly pronounced pear flavour, mildly astringent ; possesses an aroma. Harvest 1st–2nd week October. Milling period up to one week after harvesting. Cropping irregular.

Tree : Large. Numerous large limbs with wide-angled crotches giving wide framework. Branches often pendulous. Dieback from canker often severe but not crippling as growth is very strong. Extension shoots often horizontal or pendulous.

Flower : Flowering period early mid-season. Flower buds slightly pink. Flowers large, styles longer than stamens.

Leaf : Stalk 30–60 mm. Blade 30–69 mm. long, 39–60 mm. wide ; elliptical, cupped, tip obtuse, sometime acute, base cordate ; serrations present.

General notes : Probably triploid.

Staunton Squash.

Fruit : 35–46 mm. long, 38–49 mm. diameter. Shape turbinate, sometimes round or pyriform. Stalk 16–34 mm. Stem basin slight. Eye basin slight, often well defined, shallow. Calyx upright or reflexed. Sepals free or joined, brown with green patches ; stamens attached just below base of sepals. Skin yellowish green ; flush absent ; russet slight, heavy around eye basin ; lenticels fairly conspicuous, brown ; scab usually absent, sometimes very slight. Core has axial sac which is filled ; seeds dark brown or black, sometimes flattened. Flesh has slight concentration of stone cells below eye and prominent ring around core. Taste juicy, acid, astringent. Harvest 1st week October. Milling period up to one week after harvesting.

Tree : Large. Small number of large limbs. Numerous branches with twiggy, often pendulous growth. Prominent spur systems often present.

Flower : Flowering period early mid-season. Flower buds pink. Flowers large, styles longer than stamens.

Leaf : Stalk 25–48 mm. Blade 49–67 mm. long, 31–57 mm. wide ; elliptical inclined to ovate, tip acute, rarely obtuse, base rounded or cordate ; serrations present.

Tun Pear.

Fruit : 26–35 mm. long, 28–38 mm. diameter. Shape round or oblate. Stem 12–25 mm., often partially green. Stem basin absent or very slight. Eye basin absent or very slight. Calyx upright, often reflexed. Sepals upright, sometimes tubular ; stamens attached at base of sepals. Skin yellowish green ; flush rare ; russet around stem and eye, spreading to cheek ; lenticels conspicuous, light coloured ; scab slight. Core has axial sac which is usually well defined ; seeds black. Flesh has slight concentration of stone cells below eye, some stone cells around core. Taste juicy, slightly astringent, fairly pronounced pear flavour often present ; possesses a slight aroma. Harvest last week in September or 1st week in October. Milling immediately after harvesting. Cropping irregular.

Tree : Large. Few large upright limbs with narrow-angled crotches. Branches small with twiggy growth.

Flower : Flowering period mid-season. Flower buds have very slight flush.

Leaf : Stalk 27–38 mm. Blade 41–58 mm. long, 32–43 mm. wide ; elliptical, tip obtuse, rarely acuminate, base cordate sometimes round ; serrations present.

General notes : A variety common in the vicinity of Ross-on-Wye.

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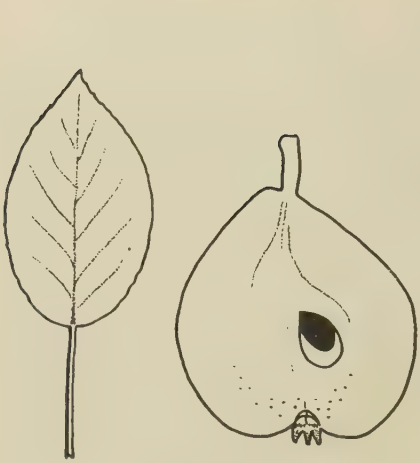
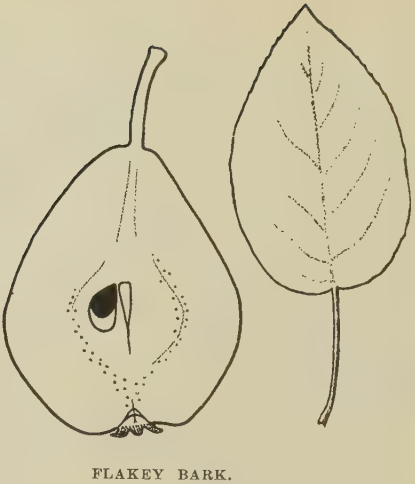
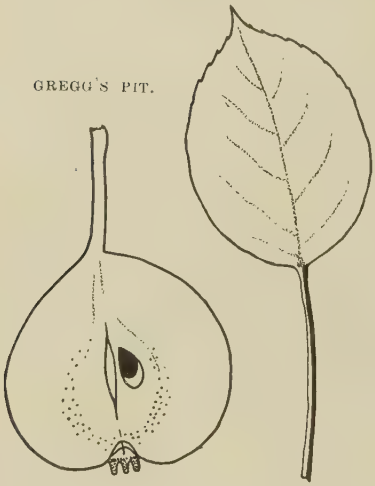


BROWN BESS.

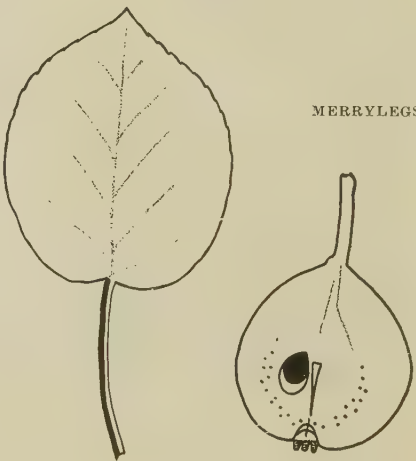


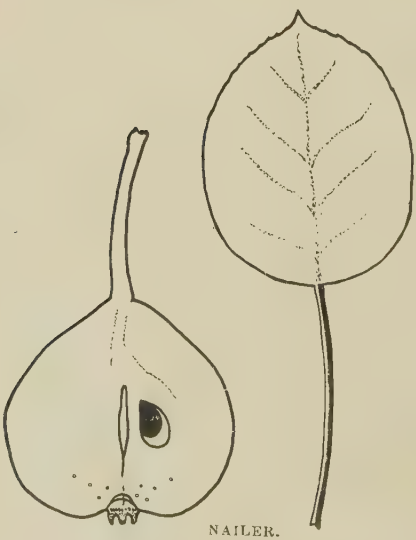
FLAKEY BARK.

GREGG'S PIT.

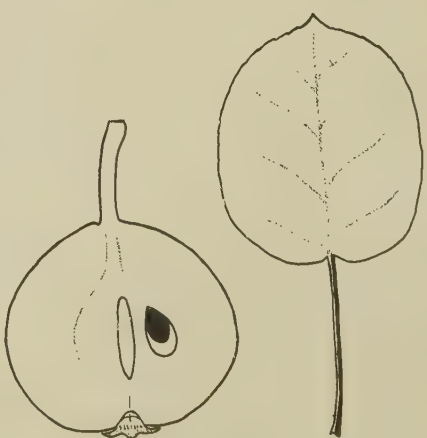


MERRYLEGS.





NAILER.



NEWBRIDGE.

BROWN BESS.

FLAKEY BARK.

GRIGG'S FIT.

MERRYLEGS.

NAILER.

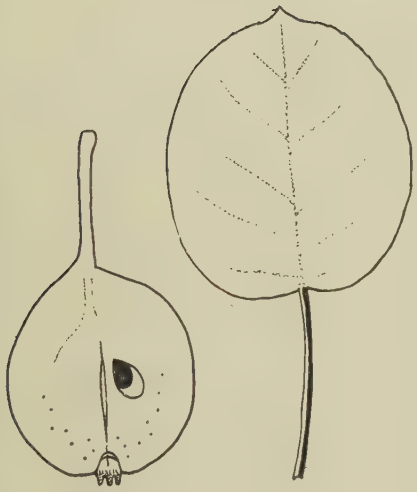
NEWBRIDGE.

PLATE VI.

PARSONAGE.

STAUNTON SQUASH.

TUN PEAR.



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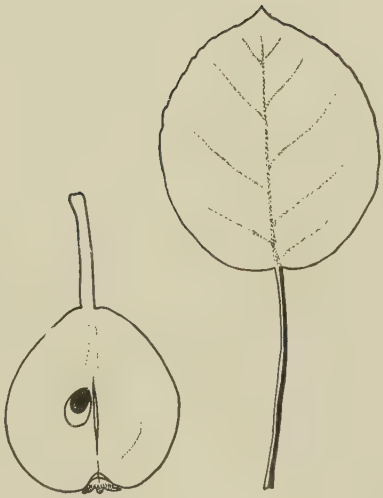
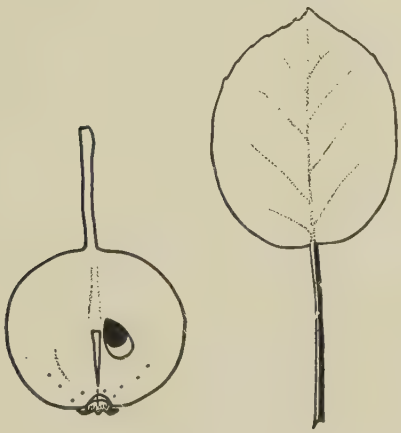


STAUNTON SQUASH.



TUN PEAR.

THE PERFORMANCE OF A CLONAL LOGANBERRY AT LONG ASHTON: I. TRAINING METHODS AND CROPPING.

By E. W. HOBBIS and E. CATLOW.

Introduction.

The failure of the loganberry to establish itself as a commercial crop in the British Isles has been related to the difficulty of obtaining planting material true to type, of high quality and known cropping history, and free from virus diseases.

Beakbane (1) showed in 1941 how mixed were the loganberry stocks then distributed in commerce; she also showed that good crops were obtainable from clonal material of the true loganberry, and that training methods had a marked effect on crop yields and on the control of Cane Spot disease (2). Further papers by Beakbane and Laburn in 1960 (3, 4) describe the cropping of five virus-tested clones of loganberry grown at East Malling with a standard method of training.

The raising at Long Ashton of a new sub-clone of the 1932 East Malling clonal loganberry, virus-tested at East Malling, was described by Hobbis and Campbell in 1957 (5). The initial propagation of this stock was undertaken under closely controlled conditions at Long Ashton and the Nuclear Stock Association was supplied with material in 1957 and 1958. During 1959 the Ministry of Agriculture introduced a Special Stock Loganberry Certification Scheme which was confined to plants raised from the Long Ashton material and designated LY.59. Nine nursery growers qualified for the certificate in 1959: fruit growers were therefore able to start planting in 1960.

In order to assess the performance of the LY.59 stock under West-country growing conditions, an experiment using three methods of training was begun at Long Ashton in the winter of 1957/58. This report covers the first year of fruiting.

Experimental.

Site. The trial field has a slope to the south, is about 150 feet above sea level and is located on a medium loam of moderate depth, derived from Keuper Marl with some overwash from limestone; the soil pH is about 7·4.

A trial of standard apple trees under permanent grass cover had occupied the site from 1928 to 1953. After this had been grubbed, a temporary ley of Italian rye grass and red clover was sown in 1954, followed by a crop of potatoes in 1956. The field was re-sown to Italian rye grass in 1957, deeply ploughed and thoroughly cultivated prior to planting in the spring of 1958.

An overall dressing of 3 cwt. sulphate of ammonia, 1 cwt. sulphate of potash and 1 cwt. superphosphate was then given and each plant was mulched with well-rotted farmyard manure. Hand and tractor cultivations to suppress weeds were carried out when necessary. In 1959 the phosphate and potash dressings and the individual plant mulch were repeated; the nitrogen application was raised to 4 cwt. sulphate of ammonia and 4 cwt. magnesium sulphate was also given. In addition an annual foliar spray of 2% magnesium sulphate (Epsom salts) and 0·5% manganese sulphate has been applied.

Planting material was raised at Long Ashton in the summer of 1957. Two methods of propagation were employed—leaf-bud cuttings and rooted tips. The former were raised in frames with bottom heat and potted-on into 6″ pots in the autumn ; the latter were rooted in a prepared compost in open frames, and the resulting plants were transferred to 6″ pots in the autumn and over-wintered in ashes in the open. All plants made rapid progress but it was noticeable that by the spring many plants raised from the rooted tips were pot-bound and in urgent need of planting out.

The material was planted direct from the pots on 10th April, 1958, by which time the developing cane was 8″ high ; the usual practice of bedding in the nursery for one year before planting-out was made unnecessary by the method of raising. The leaf-bud material was noticeably more even in development than that from the rooted tips. 450 plants were lined along the contour from E. to W., in nine rows 8 feet apart, the width being suitable for cultivations and spraying operations by narrow wheel-base tractor. The plants were spaced 6 feet in the rows, giving a density of 907 plants per acre, this number being considered necessary to achieve a high rate of cropping from the beginning.

Fencing supports consisted of concrete end-posts with 2″×2″ pickled larch stakes at 12 foot intervals, and five strands of 14 gauge galvanized wire at 2, 3, 4, 5 and 6 feet.

Layout. Originally it was intended that a standard system of training (3) should be used overall. The subsequent adoption of three training methods has required the use of an unusual split-plot randomized block design on six of the inner rows, the three remaining rows serving the dual purpose of ensuring good buffering and of demonstrating each of the three methods. There are 12 main plots, each of 20 plants, which permit comparison of leaf buds and rooted tips ; these are split into units of 10 plants for the comparison of training systems.

Training systems. The training methods employed for the cropping canes are :—

(1) open-fan on the 2nd, 3rd and 4th wires with the centre space reserved for new developing canes, the top wire (6 ft.) being kept free to accommodate new canes growing beyond this height ; (Plate VII, Figs. 1 and 2).

(2) full-fan, with fence space fully used for cropping canes, except that the bottom wire (2 ft.) is kept free for training new canes ; (Plate VII, Figs. 3 and 4).

(3) full-fan, cropping cane being secured to all wires and new canes being trained along the ground beneath the fence. (Plate VII, Figs. 5 and 6).

The first method has been shown to give the heaviest crops and to have a direct influence on the control of Cane Spot disease (2, 3), although requiring a considerable amount of work during the growing season.

The second method permits easy management of new canes during the growing season ; damage by wind is lessened ; although new canes are in a vulnerable position for Cane Spot infection, present-day spraying practice should provide a good measure of control.

The third method allows new cane to be managed simply, the growth being trained in a narrow band down the rows and kept in position by bamboo

canes pushed in alongside. Canes thus treated are also open to Cane Spot infection from the fruiting canes above. The smothering effects of young leafy canes should contribute to weed control in the summer and autumn. Growth is safe from severe damage by wind and exposure to low winter temperatures, which can cause a good deal of winter-killing ; against this must be set possible damage to young canes during the picking season unless special care is taken when reaching for the fruit.

Management.

First year. After a slow start during a cold and dry April the plants grew away rapidly in May and June. The new cane was tied-in loosely to 5′ bamboo canes tied vertically to the fence at each plant interval. The year was generally cool and, of the total rainfall of 36·6″, which was close to the normal amount, 20·2″ fell during April to September, a little more than 3″ above average for the summer months. By the end of the season some 5–8 canes per stool had been tied-in to the fence as made, with further extension growth of 2′–3′ along the top wire. In the winter the canes were brought down and tied along the fence, leaving the top wire free ; the tying-in was done effectively and quickly by 4″ lengths of paper-covered malleable wire.

Second year. The new cane was trained under the three methods, in two of which it was kept under control by using hoops made of 3′ 6″ lengths of 10 gauge galvanized wire, with the ends bent hook-wise. Cane allowed to lie on the ground was held in place by 3′ bamboo canes pushed in alongside the rows.

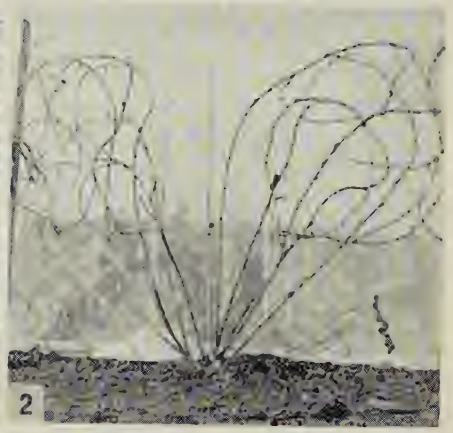
During 1959 only 10·9″ of rain fell during the six summer months, which was approximately 6″ less than average, out of a total of 32·9″ ; but the prolonged hot dry weather was interrupted by short relatively heavy storms at the beginning, in the middle, and at the end of the picking season. Rapid growth was made, however, and new cane up to 8′ long, with laterals 2′–3′, had been produced by mid-June.

All soft fruits ripened earlier than usual in 1959 : picking was started on 23rd June and finished on 23rd July. During this five-week period, three picks were made per week, sixteen picks in all ; practically one half of the total crop was picked during the second and third weeks. There was little loss of fruit due to over-ripeness and, except in the initial pick, there was no delay due to rain. Owing to the luxurious growth, however, some difficulty was encountered in reaching for the fruit, especially where the new cane was held near to or on the ground.

Immediately after fruit picking finished, the old cane was cut down to ground level. The removal of this wood called for considerable care in order to avoid damage to the new cane, and it was clearly apparent that the easiest and quickest work was done on those plants trained as an open fan, with the new cane tied upright in the centre.

Cane extension growth continued up to late October, by which time a considerable number of long laterals had been formed.

Pest and disease control. In the winter of 1958/9 a tar oil wash was given to the canes before they were trained on the wires. Two applications of derris with succinate wetter were made, on 25th May (post-blossom) and on 10th June (pre-ripening), to give maximum control of beetle, with protection against leaf hopper and aphis at the later stage. Colloidal copper was incorporated in the first derris spray to control Cane Spot infection.



Three training systems for loganberry : before and after training.
Figs. 1 and 2. Open fan with new cane upright in centre.
Figs. 3 and 4. Full fan with new cane along bottom wire.
Figs. 5 and 6. Full fan with new cane along the ground.

Cane growth.

During the training-in of new cane for fruiting in the winter 1959/60, a count was made, before and after pruning, of the number of new canes per plot of 10 stools, not more than 10 canes being left per stool. The results for each system of training and type of planting material are shown in Table I (b). The figures show little variation in the production of main cane by the three training methods or by plants which originated either as leaf buds or as rooted tips.

Table I (d) shows the time taken, in minutes, to train plots under each of the three systems of training. The advantage of System 1 in speed of training is apparent ; it is significantly quicker than System 2 at the 5% level and System 3 at the 0·1% level.

Sample measurements were taken of the total length of cane, including laterals, produced by the plants under each training system, from both leaf buds and rooted tips ; the cane left on the same plants after pruning was also measured. The mean cane length per plant, before and after pruning, is set out in feet, for a representative plant with eight new canes, in Table I (d). Although the difference is not significant, the length of new cane produced under training systems 2 and 3 was greater than under system 1. All the systems allowed ample new cane for tying-in.

The striking difference between the length of new cane made per plant, and the amount tied to the wires after pruning, immediately suggests that a 6′ spacing from plant to plant is too close and results in a great loss of cane which, given space, could be tied-in and cropped. If the spacing in the row were doubled, a big economy in the use of planting material would be possible, and it seems probable that a high level of cropping could still be attained. The bulk of a crop is generally produced by the middle third of any length of cane, much of which is sacrificed if the stools are planted as close as 6 feet apart.

Summary.

The clonal loganberry LY.59 was planted-out at Long Ashton in April, 1958, to test the relative performances of plants raised from leaf-bud cuttings and from rooted tips.

At a spacing of 8 ft. between rows and 6 ft. in the rows the mean yield of marketable fruit per plant in 1959 was 10·6 lb., equivalent to 4·3 tons per acre. The yield from the leaf-bud cuttings was significantly greater than that from the rooted tips.

Three methods of training new cane were employed ; the easiest and quickest was that in which the plants were grown as an open fan with the new cane tied upright in the centre.

The large amount of cane that had to be pruned away suggested that a wider spacing within the rows would have been advantageous.

Acknowledgments.

Grateful acknowledgments are made to Mr. G. M. Clarke and his staff for the design of the trials and the statistical examination of the results, and to Messrs. N. T. Weatheritt, D. O. Berks and K. J. Escott for help in recording. The photographs were kindly supplied by Mr. D. E. Aliband and the meteorological data by Mr. G. E. Clothier.

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MANURIAL EXPERIMENTS WITH FRUIT: III. PROGRESS REPORT ON NPK EXPERIMENTS WITH BLACK CURRANTS AT EFFORD AND LUDDINGTON N.A.A.S. EXPERIMENTAL HORTICULTURE STATIONS.

By C. BOULD.

Previous experiments with black currants at Long Ashton (Bould & Catlow 1, 2, 3 ; Wallace 4, 5) have been concerned with the response to dung and other bulky organics, and with the effects of the omission of nitrogen, phosphorus and potassium on growth and crop yield. It was shown that black currants respond to heavy dressings of dung, and that they have a relatively high requirement for nitrogen, provided that water and potassium are not limiting factors. Leaf analysis (2) showed that there was a relationship between the yield of fruit and the nitrogen status of leaves taken from the mid-third region of current shoots prior to fruit picking, optimum yield being associated with nitrogen values in the region of 2·9% in leaf dry matter.

The present experiments were designed to induce differences in soil fertility, plant growth, crop yield and leaf nutrient status so that a study could be made of the relationship between leaf nutrient concentration and plant performance, and consequently to establish leaf nutrient levels associated with conditions of deficiency, sufficiency and excess. A factorial design was chosen to enable main effects and nutrient interactions to be studied under different soil and climatic conditions.

Experimental.

Site and Soil.

Luddington. Site : rather exposed with southern aspect ; elevation about 150 ft. Soil : " Pershore " series on Lias clay. Average rainfall 24″.

Efford. Site : protected on W by a wood ; gentle southern slope ; elevation about 50 ft. Soil : " Brickearth " type, well drained but with slight mottling at 18-24″. Average rainfall 28″.

Layout and Manurial Treatments.

The design and manurial treatments at both centres are the same, but the position of the treatments within the blocks was randomized for each site. The total experimental area at each site is approximately 1·9 acres : it is divided into three blocks, each containing 27 plots. A plot consists of two rows of bushes, one row of Baldwin and the other of Mendip Cross. There are seven recorded bushes in each row ; the rows are 10′ apart and the bushes 4′ apart within the row. Each plot is guarded by a buffer row on the E and W side and by single bushes on the N and S sides. The guard bushes *within* the experimental rows are cut down annually and not allowed to fruit. The guard rows on the E and W sides are treated in the same way as the experimental rows.

Two-year old bushes were planted at Luddington in November-December, 1951, and at Efford in the autumn of 1953. Treatments commenced in the spring following planting.

There are 27 treatments, in triplicate, comprising all combinations of three levels of N, P, and K. The rates per acre are :—

N_1 ; N_2 ; N_3 = 3 ; 6 ; 9 cwt. ammonium sulphate.*
P_0 ; P_1 ; P_2 = 0 ; 3 ; 6 cwt. calcium superphosphate.
K_0 ; K_1 ; K_2 = 0 ; 1 ; 2 cwt. potassium sulphate.

Treatments are applied annually in February-March, and the fertilizers are spread evenly over the whole plot up to the buffer rows.

Management.

After planting, the bushes were cut to ground level. Because of poor growth at Luddington the bushes were cut to ground level a second time in the following autumn. Normal pruning, pest and disease control and commercial management were practised so far as consistent with the object of the experiment.

At Luddington it became clear, after a few years, that water was a limiting factor. Irrigation was started in 1957 and repeated in subsequent years as soon as the water deficit reached 2". The bushes responded well, and crop yields were enhanced. It is proposed to irrigate at Efford as soon as equipment is available.

Leaf Samples.

Leaf samples, for chemical analysis, were taken annually immediately before fruit picking. About 30 leaves were taken at random from the mid-third position of extension shoots ; one leaf only was taken from each shoot. The samples were dried at 100°C. as soon as possible and analysed for total N, P and K. Petiole tests gave a negative reaction for nitrate.

Experimental Records.

Data have been collected for plant vigour, plant losses, incidence of disease and deficiency symptoms, pruning weights, yield of fruit and leaf nutrient status.

Results.

Soil Analysis.

Analytical data for soil samples, taken on a block basis prior to treatments, are given in Table I. It will be noticed that the Efford soil was initially acid, whereas the Luddington soil was slightly alkaline and contained traces of calcium carbonate. The potassium status of both soils was approximately the same, but the Luddington soil contained approximately forty times more phosphate soluble in N/2 acetic acid. The organic matter status of both soils was on the low side.

* Because of soil acidification the form of nitrogen was changed to " Nitra-Shell " (ammonium nitrate+calcium carbonate) at Efford in 1959.

TABLE I.

SOIL DATA PRIOR TO MANURIAL TREATMENTS.

(As p.p.m. air-dry surface soil).

Site	pH	% Organic carbon	N/2 Acetic sol. P	Exchangeable K	Exchangeable Mg
Efford 1953					
Block I	5·4*	1·56	4·8	206	88
Block II	5·2*	1·70	4·2	208	94
Block III	5·2*	1·62	5·0	235	87
Luddington 1952					
Block I	>7·0	1·50	238	248	N.D.
Block II	>7·0	1·43	172	212	N.D.
Block III	>7·0	1·40	165	248	N.D.

*Magnesian limestone applied to raise the pH value to 6·5 prior to planting.
N.D. = Not determined.

TABLE II.

EFFECT OF FERTILIZER TREATMENTS ON SOIL pH AND " AVAILABLE " NUTRIENTS.

(As p.p.m. air-dry surface soil).

Treatment	Efford 1958*		Luddington 1956		
	pH	P sol. N/2 acetic	pH	P sol. in Morgan's Reagent	K
$N_1P_0K_0$	6·2	6·8	7·8	120	16
$N_3P_0K_0$	5·2	4·2	6·3	58	16
$N_1P_2K_0$	6·5	25·9	7·4	130	17
$N_3P_2K_0$	5·5	21·2	6·4	82	17
$N_1P_0K_2$	N.D.	N.D.	7·2	95	21
$N_3P_0K_2$	N.D.	N.D.	6·0	75	28

*Magnesian limestone applied in the following winter to raise the pH to 6·5, and " Nitra-Shell " substituted for ammonium sulphate in 1959.

Table II shows the effect of some treatments on soil pH and " available " phosphorus and potassium. The acidification caused by the higher rates of ammonium sulphate, which in turn reduced " available " phosphorus, will be noted.

Pruning Weights.

Pruning weights were used as an index of growth. At Efford the prunings were divided into 1-year wood (extension shoots) and 2-year wood. Results for Efford are given in Table III. With one exception, Baldwin 1958-9, nitrogen had no significant effect on 1-year wood. Significant effects were shown on 2-year wood : the higher nitrogen rates decreased pruning weights, i.e. reduced growth. In most seasons there was a positive significant response to phosphate at 6 cwt./acre, resulting in increased weights of 1- and 2-year wood. There was no significant response to potassium.

TABLE III.

BLACK CURRANTS, EFFORD ; PRUNING WEIGHTS.

(Mean yield in lb./plot of 7 bushes).

Treatment		Nitrogen								Phosphorus								Potassium	
		1-yr. wood				2-yr. wood				1-yr. wood				2-yr. wood				1-yr. wood	2-yr. wood
		N_1	N_2	N_3	F Sig.	N_1	N_2	N_3	F Sig.	P_0	P_1	P_2	F Sig.	P_0	P_1	P_2	F Sig.	F Sig.	F Sig.
Baldwin	1955–56	—	—	—	N.S.	—	—	—	N.S.	0·86	0·82	1·14	5%	—	—	—	N.S.	N.S.	N.S.
	1956–57	—	—	—	N.S.	6·16	5·81	5·35	5%	0·77	0·70	1·08	5%	5·30	5·33	6·69	0·1%	N.S.	N.S.
	1957–58	—	—	—	N.S.	—	—	—	N.S.	—	—	—	N.S.	5·51	5·20	6·45	0·1%	N.S.	N.S.
	1958–59	1·14	1·02	0·90	5%	—	—	—	N.S.	0·96	0·88	1·22	0·1%	6·95	6·87	8·16	0·1%	N.S.	N.S.
Mendip Cross	1955–56	—	—	—	N.S.	—	—	—	N.S.	—	—	—	N.S.	—	—	—	N.S.	N.S.	N.S.
	1956–57	—	—	—	N.S.	12·25	11·41	10·33	1%	2·82	2·65	3·26	5%	10·70	10·88	12·40	1%	N.S.	N.S.
	1957–58	—	—	—	N.S.	—	—	—	N.S.	1·78	1·75	2·08	1%	11·20	10·95	12·68	1%	N.S.	N.S.
	1958–59	—	—	—	N.S.	13·97	14·06	12·62	5%	2·80	2·95	3·51	0·1%	12·68	12·97	15·00	0·1%	N.S.	N.S.

F = Variance ratio ; N.S. = Not significant.

At Luddington there was no significant response to nitrogen, phosphorus or potassium with one exception : nitrogen in 1957 produced a small increase (sig. at 5% level) in total pruning weights.

Crop Yield.

Results for Efford are given in Table IV, and for Luddington in Table V.

Efford. The only significant response to nitrogen was a depression of the yield of Baldwin by the higher rates of application in 1956.

From the first year onwards there were significant responses to phosphate, at 6 cwt./acre, except with Mendip Cross in 1956. In 1959 there was a significant N × P interaction (5% level), N_1P_0 being high and N_3P_2 low.

TABLE IV.

BLACK CURRANTS, EFFORD : YIELD OF FRUIT.

(Mean yield in lb./plot of 7 bushes).

Treatment		Nitrogen				Phosphorus				Potassium			
		N_1	N_2	N_3	F Sig.	P_0	P_1	P_2	F Sig.	K_0	K_1	K_2	F Sig.
Baldwin	1955	—	—	—	N.S.	17·0	17·9	19·3	5%	—	—	—	N.S.
	1956	30·8	28·4	26·6	0·1%	26·8	26·7	32·3	0·1%	—	—	—	N.S.
	1957	—	—	—	N.S.	28·4	25·7	32·1	0·1%	27·3	27·8	31·1	5%
	1958	—	—	—	N.S.	26·1	28·3	29·2	5%	25·1	29·2	29·3	0·1%
	1959	22·9	22·0	20·3	N.S.	20·9	20·2	24·3	0·1%	20·5	21·8	23·2	5%
Mendip Cross	1955	—	—	—	N.S.	10·5	11·0	12·0	5%	—	—	—	N.S.
	1956	—	—	—	N.S.	25·0	25·7	28·0	N.S.	—	—	—	N.S.
	1957	—	—	—	N.S.	26·3	26·3	31·2	1%	—	—	—	N.S.
	1958	—	—	—	N.S.	35·5	35·5	40·2	0·1%	35·3	37·6	38·3	5%
	1959	27·5	27·0	26·4	N.S.	26·3	25·6	29·1	1%	24·3	27·5	29·3	0·1%

F = Variance ratio ; N.S. = not significant.

From 1957 onwards for Baldwin, and from 1958 onwards for Mendip Cross, there was a significant positive response to potassium. The earlier response of Baldwin was probably due to the more rapid decline in leaf-potassium in this variety (1·61% in 1954 to 0·67% in 1957, for bushes not receiving potassium fertilizer : over the same period the comparable results for Mendip Cross were 1·51 and 0·87%).

TABLE V.

BLACK CURRANTS, LUDDINGTON : YIELD OF FRUIT.

(Mean yield in lb./plot of 7 bushes).

Treatment		Nitrogen				Phosphorus	Potassium
		N_1	N_2	N_3	F Sig.	F Sig.	F Sig.
Baldwin	1954	22·9	24·2	24·2	N.S.	N.S.	N.S.
	1955	31·4	31·6	30·1	N.S.	N.S.	N.S.
	1956	7·1	6·7	6·1	N.S.	N.S.	N.S.
	1957	28·4	29·0	25·4	N.S.	N.S.	N.S.
	1958	46·8	51·9	50·3	N.S.	N.S.	N.S.
	1959	62·4	65·8	64·0	N.S.	N.S.	N.S.
Mendip Cross	1954	14·4	14·9	14·7	N.S.	N.S.	N.S.
	1955	34·4	34·8	34·7	N.S.	N.S.	N.S.
	1956	11·2	8·7	8·4	5%	N.S.	N.S.
	1957	32·7	28·2	25·8	0·1%	N.S.	N.S.
	1958	52·4	53·4	53·8	N.S.	N.S.	N.S.
	1959	49·8	52·6	47·8	5%	N.S.	N.S.

F=Variance ratio ; N.S.=Not significant.

TABLE VI.

BLACK CURRANTS, EFFORD ; LEAF COMPOSITION.

(As % dry matter).

mpling date		Nitrogen (N)				Phosphorus (P)				Potassium (K)			
		N_1	N_2	N_3	F Sig.	P_0	P_1	P_2	F Sig.	K_0	K_1	K_2	F Sig.
	9/7/54	2·73	2·86	2·86	1%	0·240	0·232	0·228	N.S.	1·61	1·57	1·70	N.S.
ldwin	10/7/57	2·74	2·82	2·86	1%	0·241	0·262	0·253	1%	0·67	0·85	1·07	0·1%
	15/7/58	2·95	2·98	3·06	1%	0·294	0·314	0·333	0·1%	0·85	1·15	1·41	0·1%
	9/7/54	2·76	2·75	2·86	N.S.	0·210	0·219	0·230	N.S.	1·51	1·63	1·60	N.S.
ndip Cross	10/7/57	2·61	2·75	2·82	0·1%	0·195	0·217	0·217	0·1%	0·87	1·05	1·22	0·1%
	15/7/58	2·93	3·01	3·02	5%	0·241	0·269	0·281	0·1%	1·00	1·27	1·46	0·1%

F=Variance ratio.

Luddington. Results are given in Table V. With the exception of nitrogen, which at the higher rates depressed the yields of Mendip Cross in 1956, 1957 and 1959, fertilizers had no significant effect on crop yield. This was probably due to the higher soil fertility, which resulted in sufficiency concentrations of leaf nutrients (see Table VII).

TABLE VII.

BLACK CURRANTS, LUDDINGTON : LEAF COMPOSITION.

(As % dry matter).

	Sampling date	Nitrogen (N)				Phosphorus (P)				Potassium (K)			
		N_1	N_2	N_3	F Sig.	P_0	P_1	P_2	F Sig.	K_0	K_1	K_2	F Sig.
Baldwin	24/6/53	2·61	2·74	2·80	0·1%	0·300	0·315	0·315	N.S.	1·58	1·66	1·58	N.S.
	7/7/54	2·57	2·73	2·80	0·1%	0·261	0·288	0·301	0·1%	1·93	1·94	2·02	N.S.
	15/7/55	2·75	2·89	2·96	0·1%	0·345	0·361	0·397	0·1%	2·02	2·05	2·11	N.S.
	9/7/58	2·76	2·82	2·91	1%	0·301	0·356	0·431	0·1%	1·34	1·48	1·54	0·1%
Mendip Cross	24/6/53	2·80	2·80	2·90	5%	0·295	0·300	0·310	N.S.	1·62	1·65	1·61	N.S.
	7/7/54	2·64	2·82	2·85	0·1%	0·249	0·264	0·304	0·1%	1·75	1·75	1·75	N.S.
	15/7/55	2·70	2·90	3·00	0·1%	0·294	0·334	0·368	0·1%	2·07	2·16	2·13	N.S.
	9/7/58	2·79	2·90	3·00	0·1%	0·326	0·413	0·591	0·1%	1·49	1·63	1·64	0·1%

F = Variance ratio.

Leaf Analysis.

Efford. The results for 1954 (the year prior to the first crop) and for 1957 and 1958 (prior to the correction of soil acidity due to the higher rates of ammonium sulphate) are given in Table VI. By 1957, nitrogen, phosphorus and potassium treatments had significantly altered the composition of the leaves, the highest leaf concentrations being positively related to the highest fertilizer dressing for each element. The main effects only are given in Table VI.

Nitrogen fertilizer depressed leaf phosphorus in 1957 and 1958 in both varieties, as shown below :—

	% Leaf Phosphorus			
	Baldwin		Mendip Cross	
	1957	*1958*	*1957*	*1958*
N_1	0·260	0·334	0·221	0·285
N_2	0·255	0·305	0·208	0·258
N_3	0·243	0·302	0·201	0·249

Potassium fertilizer had a small, but significant, depressing effect on leaf phosphorus in Mendip Cross.

	% Leaf Phosphorus	
	1957	*1958*
K_0	0·214	0·279
K_1	0·210	0·262
K_2	0·205	0·251

Luddington. From 1953 onwards nitrogenous fertilizer had a significant effect on leaf nitrogen ; from 1954 onwards phosphatic fertilizer had a significant effect on leaf phosphorus, and by 1958 potassic fertilizer had significantly affected leaf potassium. Leaf nitrogen covered the same range as at Efford ; leaf phosphorus values were much higher ; the decline in leaf potassium was less rapid and the values were generally higher.

Discussion.

The most surprising result from these two experiments was the lack of response to fertilizer nitrogen at rates above 3 cwt./acre, since black currants are known to have a high nitrogen requirement. Failure to respond to nitrogen is thought to be due to water deficiency. Irrigation was started at Luddington in 1957 and the effect on yield of fruit was evident in 1958 and 1959 ; in both these years N_2 (6 cwt./acre) gave the highest yield of fruit, and in 1959 the differences for Mendip Cross were significant at the 5% level. It will be noted from Table VII that the leaf nitrogen for Mendip Cross at Luddington on N_2 plots in 1958 was 2·9% in leaf dry matter, a value suggested by Bould and Catlow (2) as being optimum for black currants.

At Efford, fertilizer nitrogen at rates above 3 cwt./acre depressed growth and yield of fruit. This effect is thought to be due to soil acidification, which rendered soil- and applied-phosphate less available (see Table II). Leaf phosphorus was lower than at Luddington (see Tables VI and VII), and was probably limiting growth. A check was made on leaf-calcium in the 1957 Efford samples. The values for N_3 plots ranged from 2·81 to 3·22% Ca in leaf dry matter ; hence calcium was not a limiting factor on these high nitrogen plots.

There was no response to phosphatic fertilizers at Luddington. From Table VII it will be seen that in most years the leaf phosphorus was greater than 0·3% in dry matter at the fruit ripening stage. This value would appear to be sufficient for normal growth when other nutrients are not limiting.

At Efford, phosphatic fertilizers at 6 cwt./acre had a significant positive effect on growth and crop yield from the first cropping season onwards. " Available " soil phosphate was very low and leaf phosphorus at the fruit ripening stage was much lower than for similar treatments at Luddington. From 1954 to 1957, the mean values for P_0 plots were 0·24% P for Baldwin and 0·20% P for Mendip Cross. These values are clearly too low for optimum growth, and the effects would probably have been more marked had water supplies been adequate.

There was no response to potassic fertilizers at Luddington. It will be seen from Table VII that the leaf potassium values were relatively high, particularly in the first three growing seasons. The values for 1958 are lower, but this was probably because the heavier crop in that year caused a depletion in leaf potassium ; even so, the values for K_0 plots were reasonably high.

At Efford, leaf potassium was adequate in the first season but the values fell rapidly. By 1957, potassium was clearly limiting crop yield, although it was not affecting growth as measured by pruning weights. It will be noticed that crop yield was affected one year earlier with Baldwin than with Mendip Cross. Reference to Table VI shows that the general level of leaf potassium in 1957 was lower in Baldwin than in Mendip Cross. It would appear that values

in the region of 1·5% K in leaf dry matter at the fruit ripening stage are adequate for normal growth and cropping, and that values below 1·0% are deficient ; between 1·0% and 1·5% K in leaf dry matter yield is marginal.

These experiments are being continued, and the effects of irrigation on growth, yield and leaf-nutrient status will be investigated.

Acknowledgments.

I am greatly indebted to the Directors and Staff at Efford and Luddington for their continued interest and help with these experiments. In particular, I should like to thank Miss H. M. Hughes of Efford and Mr. J. Ingram of Luddington, who were responsible for the management and general supervision of field records. Thanks are also due to the Statistics Section, East Malling Research Station, for the design of the experiments, to Mr. G. M. Clarke of Long Ashton Research Station for the statistical analysis of the results, and to Mr. E. G. Bradfield and Mr. W. K. Hancock for carrying out the chemical leaf analyses.

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SPRAY APPLICATION PROBLEMS: LX. THE UPTAKE OF MERCURY BY PLANT TISSUES.

By J. A. PICKARD and J. T. MARTIN.

In 1957, Bramley apple fruits were found (1) to contain 0·05 parts per million (p.p.m.) of mercury (Hg) following a normal programme of spraying with phenylmercuric nitrate for scab control. About 20 per cent. of the contamination occurred in the peel of the fruits, 70 per cent. in the flesh and the remainder in the core. Absorption of mercury into the leaves was also found. An investigation of the efficiency of phenylmercuric acetate in controlling the coffee berry disease (2) indicated that mercury absorbed by coffee leaves could be translocated to new emerging foliage. Further observations on the absorption of mercury into apple shoots, leaves and fruits, on its distribution within fruits and on its uptake by roots from nutrient solution and soil are recorded in this progress report.

The Analytical Method.

A critical examination was made of the analytical method to ensure the quantitative recovery of very small amounts of mercury with a minimum of interference from the plant material. The organic matter is removed by hot acid digestion, which needs to be carefully controlled to prevent the loss of mercury. The mercury is then extracted from the acid digest with dithizone. This reagent is very sensitive but lacks specificity, and other metals, such as copper, that occur naturally in the plant material may interfere. To overcome this, complexes of the metals with EDTA (disodium ethylenediamine tetra-acetate dihydrate) were formed, as suggested by Vasak & Sedivec (3); only the complexes of mercury and of gold and silver (unlikely contaminants) then react with dithizone under the conditions of the test. Other precautions had to be taken to prevent the oxidation of the dithizone during the extraction of the mercury. The details of the analytical procedure have been published elsewhere (4).

Experimental.

Material was obtained from two commercial orchards in Hereford (sites A and B), from one in Somerset (site C) and from experimental plots at Long Ashton (site D).

Mercury residues and distribution of mercury in apple fruits.

Bramley fruits (1958 crop) from orchard A, which had been given a " normal commercial spray treatment " for scab control, showed 0·04 and 0·03 p.p.m. Hg. The Bramley orchard C received in 1959 three full-coverage pre-petal-fall applications of phenylmercuric nitrate at full strength, followed by seven post-petal-fall treatments at half strength: fruits harvested three months after the last application showed 0·04 p.p.m. Hg (four determinations). The results confirm our earlier finding that Bramley apples contain about 0·05 p.p.m. Hg after commercial spraying.

The fruits from orchard A were small. Two samples were peeled, not too thinly, and the peel and the flesh (including the core) were analysed separately. The orchard C fruits, which were much larger, were thinly peeled and the fractions examined. The average results per apple are shown in Table I.

TABLE I.

DISTRIBUTION OF MERCURY BETWEEN THE PEEL AND FLESH OF APPLE FRUITS.

Site		Weight	Hg	
		(g.)	(μg.)	(p.p.m.)
A	Peel	17	2·6	0·16
	Flesh	99	0·6	0·01*
A	Peel	17	2·8	0·15
	Flesh	104	1·0	0·01*
C	Peel	17	3·7	0·22
	Flesh	280	8·1	0·03*

*after deduction of blanks on untreated fruits.

In the fruits from site A, 70–80 per cent. of the mercury was located in the peel. In those from site C, the reverse was found, almost 70 per cent. of the mercury being present in the fleshy tissue.

An attempt was made in a later experiment to determine more exactly the distribution of mercury in treated fruits. Bramley trees (site D) were sprayed in September with 0·0125 per cent. Hg as phenylmercuric acetate ; the fruit was picked three weeks later, and kept in a cold store until March of the following year. The fruits were then peeled, as thinly as possible ; the calyx and stem cavity ends were removed and zones of fleshy tissue $\frac{1}{2}$, 1 and 1 cm. deep were taken progressively from the periphery inwards. The remainder consisted of the central portion of the core containing the seeds. The fractions were analysed separately ; the mean results per apple are shown in Table II.

TABLE II.

DISTRIBUTION OF MERCURY IN APPLE FRUIT.

Site		Weight	Hg	
		(g.)	(μg.)	(p.p.m.)
D	Peel	9·5	21·3	2·21
	Flesh 0·5 cm. deep	17·4	0·63	0·04
	Flesh 0·5–1·5 cm. deep	30·0	0·20	0·01
	Flesh 1·5–2·5 cm. deep	32·2	0·17	0·01
	Central core	23·3	0·23	0·01
	Calyx and stem cavity ends	45·0	0·50	0·01

Another test showed 1·4 p.p.m. Hg. in the peel, 0·02 p.p.m. in the zone immediately beneath the skin and 0·01 p.p.m. throughout the remainder of the internal tissue.

The rate of penetration of mercury into apple leaves and fruits.

To study the rate of penetration, surface deposits were recovered from treated Worcester apple leaves and fruits at intervals over a period of one week, during which no rain fell. Bush trees were sprayed to full coverage early in September with phenylmercuric acetate (0·0125 per cent. Hg in the diluted wash). Soon after the deposit had dried, leaf tissue of 40 sq. cm. surface area or individual fruits of about 120 sq. cm. surface area were immersed with agitation, for 10 minutes at each immersion, in four successive portions of sodium acetate-hydrochloric acid buffer solution at pH 5, to which a wetter had been added. Mercury was found in the first and second washings, but none in the third and fourth. After immersion, the fruits were peeled, and the leaves and fruit peel were acid-digested to determine the mercury that had penetrated. Determinations of total mercury were also made by digestion of other treated, but unwashed, leaves and fruit peel : tests on unsprayed material gave insignificant values. The results, expressed as μg. Hg/sq. cm. of plant surface, are shown in Table III.

TABLE III.

PENETRATION OF MERCURY INTO APPLE LEAVES AND FRUITS.

(μg./sq. cm.).

	Days after spraying.				
	0	1	2	3	6
Leaves					
Surface mercury	0·43	0·20	0·13	0·08	—
Absorbed mercury	0·25	0·30	0·38	0·53	—
Total mercury by digestion ..	0·80	0·55	0·65	0·53	—
Fruits					
Surface mercury	0·25	—	0·05	—	<0·01
Absorbed mercury	0·09	—	0·28	—	0·25
Total mercury by digestion ..	—	—	—	0·33	0·30

Within a few days most of the mercury had penetrated beyond the reach of surface washing. There was no indication of a significant loss of mercury from the surface by volatilization.

The mercury-dithizone complexes obtained from the washings showed maximum absorption at 475 mμ, indicating that at the end of one week the mercury present on the surface was still in the form of phenylmercuric acetate (the complex with inorganic mercury shows maximum absorption at 490 mμ). The nature of the mercury absorbed into the leaves and peel was obscured by the acid digestion process, which transformed it to the inorganic state. An attempt was therefore made, using another procedure, to ascertain both the form and the localization of the mercury in the fruit peel. After removing the surface deposit, the peel was extracted with acetone, which removed a further small amount of mercury, still as phenylmercuric acetate. The peel was then treated at 25°C. with 0·5 *N* ethyl alcoholic potash to break up the cutin. No mercury was liberated with the cutin acids : the mercury, still present in considerable amount, was tightly bound on the cellulosic residue of the cuticle and all attempts to recover it by solvent extraction failed.

Similar results were obtained in the examination of the cuticle of sprayed Bramley fruits.

Distribution of mercury in apple shoots.

The question has been raised from time to time whether the repeated application of mercury sprays may lead eventually to damage to the apple tree. Information was therefore sought on the levels of mercury in shoots that had received treatment for considerable periods. Woody material (Bramley) was obtained late in the year from orchard A, which had received a commercial mercury spray programme for six years. Prunings were obtained from trees (Blenheim Orange) on site B that had been sprayed thirty-two times, during five years, with phenylmercuric nitrate at reduced strength. Lengths of shoot were peeled and the bark and internal wood analysed separately. The results are shown in Table IV.

TABLE IV.

DISTRIBUTION OF MERCURY IN APPLE SHOOTS.

Site		Weight	Hg	
		(g.)	(μg.)	(p.p.m.)
A	Bark	8	32·5	4·10
	Wood	17	3·0	0·18
A	Bark	8	29·5	3·55
	Wood	17	3·3	0·19
A	Bark	8	31·2	3·85
	Wood	17	2·5	0·15
B	Bark	20	6·1	0·31
	Wood	89	0·9	0·01
B	Bark	20	30·6	1·53
	Wood	50	8·0	0·16
B	Bark	20	23·5	1·18
	Wood	54	3·8	0·07

Six more samples of bark from site B showed from 0·9 to 2·8 p.p.m. The leaves from the shoots from site A contained 9 p.p.m. and the buds 3·5 p.p.m. Hg. The results show that much of the mercury retained by the shoots is located in the bark : subsequent work has indicated that the mercury that penetrates occurs largely in the zone immediately beneath the bark.

The uptake by plants of mercury from nutrient solution and soil.

Dwarf bean plants, grown in sand, were transferred when small to beakers containing standard nutrient solution to which mercury (0·06, 0·11 and 0·28 μg./ml.) was added as phenylmercuric acetate ; four plants were used for each treatment. The solutions were renewed after 14 days and plants were taken for analysis one and three weeks later. A second experiment was run concurrently ; the solutions were renewed after 14 and 28 days and the plants

were examined 12 days later. The roots were washed in a jet of water, the roots and tops were weighed fresh and examined for mercury. The average results per plant for each treatment are given in Table V.

TABLE V.

UPTAKE OF MERCURY FROM NUTRIENT SOLUTION BY DWARF BEAN PLANTS.

Mercury in solution	Growth period	Part of plant	Weight	Hg	
(μg./ml.)	(days)		(g.)	(μg.)	(p.p.m.)
First Experiment					
0·06	23	Tops	7·9	7	0·90
		Roots	3·5	24	6·9
0·11	21	Tops	3·9	1	0·13
		Roots	3·0	59	19·7
0·28	45	Tops	6·4	1	0·16
		Roots	5·5	67	12·2
Second Experiment					
0·06	70	Tops	11·7	1	0·09
		Roots	6·2	33	5·3
0·11	70	Tops	6·2	1	0·13
		Roots	4·2	61	14·5
0·28	70	Tops	3·4	<1	0·09
		Roots	2·7	80	29·6
nil	70	Tops	13·6	nil	nil
		Roots	6·8	nil	nil

All three concentrations of mercury in the nutrient solution depressed growth. A little mercury appeared in the tops of the plants : the roots contained appreciable amounts, up to 30 p.p.m.

A similar experiment was made with lettuce plants, using 0·03, 0·06 and 0·11 μg. Hg/ml. of nutrient solution. The lowest concentration appeared to stimulate growth, but the highest again depressed that of both tops and roots. Mercury appeared in both tops and roots (0·06 and 1·5 p.p.m. respectively at the highest level of treatment).

Preliminary tests were made on the uptake of mercury by the leaves and roots of broad bean plants grown in soil. The lower leaves of plants 18–24″ high were painted with a phenylmercuric acetate solution containing 50 μg. Hg/ml. After 9 days the leaves above those treated showed 0·11 p.p.m. mercury, but none had reached the apices of the plants. Two months later, the seeds taken from the pods subsequently formed on the treated plants contained 0·2 p.p.m. Hg. The roots of broad bean plants grown in soil to which mercury as phenylmercuric acetate had been added in solution (10,000 μg.Hg/pot) showed after 4 months a mean level of contamination of 5·7 p.p.m. These tests were made late in the year and will be repeated under more favourable growing conditions.

Following an enquiry by the Rosewarne Experimental Horticulture Station, an examination was made of the roots and curds of broccoli plants which had been treated at the seedling stage with calomel or mercuric chloride.

Roots, unwashed, had been dipped in calomel (2 oz/pint) or chloride (1:1600 solution); 1 pint of each treated 500 plants. Fully-grown plants, with soil attached to the roots, were received from Rosewarne; the soil was detached, the roots washed with a jet of water, and the soil, roots and curds were analysed separately. The results are shown in Table VI.

TABLE VI.

MERCURY CONTENTS OF CURDS AND ROOTS OF BROCCOLI PLANTS AND OF SOIL.

Treatment	Hg (p.p.m.)		
	Curds	Roots	Soil
Calomel	0·01, 0·01 0·01, 0·01	0·08, 0·11 0·12, 0·08	0·13
Mercuric chloride	0·01, 0·01 0·01, 0·01	0·07, 0·07 0·10, 0·06	0·14
Untreated	0·01, 0·01	0·03, 0·03	0·11, 0·13

The curds from the treated plants were identical, on analysis, with those from the untreated plants, all the samples containing the very low level of 0·01 p.p.m. Hg. Appreciable quantities of mercury (0·1 p.p.m.) were found in the roots of the treated plants and in the soil.

Discussion.

The work has confirmed our earlier finding that Bramley fruits are likely to contain about 0·05 p.p.m. Hg after normal commercial spraying for scab control. Ross & Stewart (5) report a similar level of contamination of fruits in Nova Scotia. In our tests, small fruits from one commercial orchard held most of the mercury in the peel. Large fruits from another site, however, showed a greater degree of contamination of fleshy tissue, more in line with our earlier results (1) and with those obtained by Ross & Stewart (5). Our tests on Bramley apples sprayed when almost fully-grown indicated that the zone immediately below the cuticle was more heavily contaminated than the rest of the fleshy tissue; the relative proportions of mercury found in the peel and flesh may thus depend to some extent upon the thickness of the skin taken for analysis. The factors governing the absorption of mercury into, and its distribution throughout, the fruit are not yet clear. There seems to be no significant loss of mercury by volatilization from the surface, the mercury penetrates within a few days beyond the reach of surface washing, and there is a tendency for it to be firmly held in the cuticle. We have tended to assume that the mercury found in the flesh and central core has obtained access *via* the skin; Ross & Stewart (5), however, faced with discrepant data, suggest that the mercury in the fruit may come from other parts of the tree. It is possible that mercury may be brought in with nutrients as the fruit swells, and this merits further examination.

The penetration of mercury into Worcester apple leaves within a few days, was also found. The initial deposit on the leaves, after spraying with 0·0125 per cent. Hg was 0·8 μg./sq. cm. and that on the fruits 0·3 μg./sq.cm., a

reflection of the greater ease with which the leaf surface is wetted. Even at this excessively high concentration of mercury in the spray fluid, fruits sprayed when fully grown and analysed immediately were contaminated only to the extent of 0·3 p.p.m. So far as it has been possible to make tests without the risk of changing the nature of the mercury, it appears to persist in the organically-combined form.

The distribution of the mercury present in apple shoots that had been sprayed for a number of years showed that most of the mercury was retained in the bark (average in all tests = 88 per cent. of total mercury present). So long as this occurs, there is not likely to be a great risk of damage to the tree. Further work is planned to ascertain what level of mercury shoots will withstand, and whether, in fact, any build-up of mercury occurs from year to year.

Although there is no question of using mercury on dwarf and broad beans and lettuce, these plants provided interesting data on the uptake of mercury from nutrient solution and soil. Stunting of the plants resulted from the higher concentrations used in the nutrient solution. From this, and from soil, mercury was taken up by the roots in appreciable amounts, but little translocation to the tops occurred. An indication was obtained of the passage of mercury from treated leaves to the seeds of broad bean, but this has yet to be confirmed.

A low content of mercury (0·01 p.p.m.) was found in the curds of the treated and untreated broccoli plants from Rosewarne. The optical densities of the dithizone complexes recorded in these analyses, while too low to determine the wavelengths of maximum absorption, were invariably in excess of the very low reagent blanks. The roots of the treated plants contained about 0·1 p.p.m. : those of the untreated plants 0·03 p.p.m. Hg. The mercury in the untreated roots represents the natural uptake from the soil : the additional mercury (0·07 p.p.m.) found in the treated roots presumably came from the treatments. Monier-Williams (6) quotes values obtained by German workers of up to 0·025 p.p.m. Hg in vegetables and fruit and of 0·1 to 0·3 p.p.m. in soils. We have found (1) 0·01 p.p.m. Hg in untreated apple fruits after the subtraction of blank values and Ross & Stewart (5) report the presence of small amounts of mercury in apples which had not received a mercury fungicide. Stone, Clark & Jacks (7) found 0·017 p.p.m. in the skin and 0·006 p.p.m. in the pulp of untreated apples. The extent to which naturally-occurring soil mercury is taken up by fruits and vegetables needs further examination.

Summary.

Experiments on the penetration and distribution within plant tissues of mercury applied as phenylmercuric acetate are described. Absorption occurs within a few days from the surfaces of apple leaves and fruits : some is firmly held in the cuticles of the fruits and some appears in the flesh. Mercury is taken up by the roots of plants from nutrient solution or soil, but little is translocated to the tops. The results of the examination of the curds and roots of broccoli plants treated at the seedling stage with calomel or mercuric chloride are reported and the natural mercury content of fruits and vegetables is discussed.

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SPRAY APPLICATION PROBLEMS: LXI. THE PERSISTENCE OF LONCHOCARPUS DEPOSITS ON PLANTS.

By J. T. MARTIN.

Introduction.

Observations on insect control have shown that derris and lonchocarpus insecticides quickly lose their activities when sprayed on plants. Japanese workers noted that derris deposits remained effective for about two days ; in the U.S.A., some activity of lonchocarpus deposits on cabbages remained after five days and derris deposits persisted longer on bean plants in the shade than in sunlight. Few data are available on the rate of loss of toxicity under conditions in this country. At Long Ashton, work on the control of apple and plum sawfly larvae with derris and lonchocarpus suggested that the duration ot toxicity of deposits which were protected to some extent in the calyx cups was not less than four days (1, 2). Subba Rao and Pollard (3) investigated the photodecomposition of rotenone in the laboratory and estimated that field deposits would probably lose most of their activities in 5–6 average spring days and in 2–3 summer days. In 1958, methods for the determination of rotenone in lonchocarpus root and resin were re-examined (4) ; in 1959, further chemical work was done on the persistence of lonchocarpus deposits in the field.

Derris and lonchocarpus sprays are standardized on rotenone content (usually 0·004 per cent.) but other insecticidal compounds, notably deguelin and elliptone, are present in varying amounts. To follow degradation in the field, a chemical method was required which was sufficiently sensitive to determine the low levels of deposits given by sprays of this strength and which would also differentiate between the toxic compounds and their non-insecticidal derivatives. Gross and Smith (5) described a colorimetric test for rotenone in which a red colour was formed by the action of alcoholic potassium hydroxide and nitric acid-sodium nitrite solutions ; deguelin responded to the test, but dehydrorotenone and dehydrodeguelin, the inactive primary decomposition products of rotenone and deguelin, did not. Goodhue (6) improved the method, increasing its sensitivity twenty times. Jones (7) found that rotenone, deguelin and elliptone gave comparable colours in the test, which therefore seemed suitable for following the loss in the activity of deposits.

Experimental.

An experiment was carried out in 1951, the results of which were not published. Gooseberry bushes bearing developing fruits were sprayed to run-off in June with an acetone-sulphonated lorol formulation of lonchocarpus resin, at 0·004 per cent. rotenone. Leaves and fruits were taken soon after spraying and again at intervals during a period of one week.

Each sample of whole leaves or fruits was washed with three successive portions of benzene, the solvent was removed and the residue dissolved in 3 ml. of acetone. 2 ml. were added of a mixture of aqueous potassium hydroxide solution (40 per cent., 1 vol.) and alcoholic sodium nitrite solution (0·1 g. dissolved in 6 ml. water and made up to 100 ml. with absolute ethyl alcohol, 7 vols.) and the solution was kept at 27·5°C. for 5 minutes. 5 ml. of sulphuric acid (1 vol. of concentrated acid to 3 vols. of water) were added, and the colour formed was compared, after 15 minutes, with that given by a standard rotenone solution. Wax precipitated in the analysis of the fruits was removed by adding water and shaking with ether.

The method was not sufficiently sensitive to detect satisfactorily the deposits from sprays containing 0·004 per cent. of rotenone ; the concentration of rotenone was therefore raised to 0·02 per cent. and the experiment was repeated. The fruits then showed initial deposits of 1·8 p.p.m. and the leaves 45 p.p.m. (as rotenone). Two days later, the levels of deposits were unchanged, and after six more days the fruits showed 0·5 p.p.m. and the leaves 24 p.p.m. Some fall in the residue, as p.p.m., on the fruits resulted from their growth, but both the leaves and fruits retained active compounds after one week. The weather during this period was generally dull with very little rain.

In 1959 experiments were made with pure rotenone and lonchocarpus resin to determine the best conditions for the test. Higher intensities of colour were produced at 0°C. than at room temperature ; those given by rotenone at 0°C. and room temperature, and by the resin at room temperature, were linear when plotted against concentration, but those given by the resin at 0°C. were not. Alkali washing of a benzene solution of the resin to remove phenolic materials before the test gave colours of slightly lower intensities. The optical densities, measured at 540 mμ in a 1 cm. cell, are shown in Table I.

TABLE I.

OPTICAL DENSITIES GIVEN BY ROTENONE AND LONCHOCARPUS RESIN.

Weight (μg.)	Rotenone		Lonchocarpus resin	
	At room temperature	At 0°C.	At room temperature	After alkali washing ; at room temperature
30	0·100	0·125	—	—
60	0·205	0·265	0·098	0·075
120	0·395	0·510	0·175	0·156
240	—	—	0·345	0·310

Two field experiments were then made with lonchocarpus resin, using black currant bushes treated to run-off in July. The initial deposits on the leaves from an acetone-succinate spray fluid containing 0·004 per cent.

rotenone again could not be detected satisfactorily ; the tests were therefore made using 0·04 per cent. rotenone and the wetter at 0·025 per cent. Circular discs (100, each 1 sq. cm. area) were punched from the leaves and washed in five successive portions of 5 ml. of acetone at room temperature. Subsequent hot extraction showed that the washing procedure removed all the deposit. Activated charcoal (0·05 g.) was added to the combined washings, and after two minutes the solution was filtered, the solvent removed and the residue dissolved in 3 ml. of acetone for analysis. The reaction was carried out at room temperature ; the average results, allowing for controls, are shown in Table II.

TABLE II.

LONCHOCARPUS DEPOSITS ON BLACKCURRANT LEAVES.

Experiment	*Deposit, as μg. rotenone/sq. cm.*			
	Initial	After 1 day	After 2 days	After 3 days
1	0·60	0·05	—	nil
2	0·62	0·18	0·06	—

The active compounds in the deposits declined rapidly. In the first experiment, the application of the spray was followed by three hot sunny days (11–13 hours of sunshine and maximum temperature 79–81°F.) with no rain ; in the second experiment spraying was followed by two dull days during which 0·89″ and 0·62″ of rain fell.

The results are recorded in this note since further chemical work on rotenone-containing deposits is not contemplated at present. They confirm biological observations that under dull, cool conditions with no rain, lonchocarpus deposits in the field retain unchanged insecticidal compounds for one week or longer, and that under conditions of bright sunlight and high temperatures their activities are quickly lost.

Summary.

Chemical assay of lonchocarpus deposits on plants in the field showed that under dull cool conditions, with no rain, insecticidal compounds persisted for at least one week, and that under conditions of bright sunlight and high temperature the toxic compounds were quickly lost.

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SPRAY APPLICATION PROBLEMS: LXII. THE LIMITS OF VISIBILITY OF FLUORESCENT TRACERS IN SPRAY LIQUIDS.

By ANN R. TAPSCOTT and H. R. MAPOTHER.

It has been suggested that, when using tracers with low-volume spraying machines, fluorescence may not be visible because of the small droplet size and the degree of dispersion given by such machines, although adequate cover may be present. The behaviour of tracers at the lower limits of visibility has therefore been investigated.

Experimental.

For the first experiments a spray fluid containing both tracer and copper was applied to apple trees by a small power-operated mistblower and to individual leaves by a hand-operated atomiser. The range of droplet sizes given by the atomiser was 25-50 microns diameter; that given by the mistblower was estimated at 50–250 microns. Copper was included since chemical estimation of deposits is simple and rapid; it was used at 3%, i.e. about

TABLE I.

NUMBERS OF FLUORESCENT PARTICLES AND WEIGHTS OF COPPER ON APPLE LEAVES.

Tracer	Very Sparse		*	Sparse		*	Light		*
	Fluorescent particles		Cu (µg.)	Fluorescent particles		Cu (µg.)	Fluorescent particles		Cu (µg.)
	T	B		T	B		T	B	
Mistblower									
0·1% Lissamine	6	0	0·2	34	46	4·3			
	8	0	0·2	37	0	0·9			
	12	0	0·6	26	0	2·1			
	10	0	0·3	50	0	1·0			
	13	0	0·6	35	0	1·0			
Atomiser									
0·025% Saturn Yellow	0	1	0·6	12	4	0·9	1000	0	31
	3	0	0·9	10	0	1·3	700	0	27
	2	0	0·3	32	3	2·5	1000	0	37
	3	2	0·8	16	2	0·6	1000	0	43
	2	4	0·7	50	3	2·9	1000	0	37
0·1% Lissamine	2	1	1·2	6	5	3·3	0	1000	28
	0	4	2·0	7	0	0·9	0	500	13
	0	0	0	18	1	2·9	50	1000	22
	0	5	0	12	50	2·0	0	100	38
	6	1	2·1	22	0	2·7	50	100	41
0·05% Lissamine	4	2	0·9	0	40	8·8	100	40	38
	1	1	0·2	3	40	5·3	50	12	18
	0	2	1·8	13	8	6·4	60	50	42
	4	0	0·8	8	40	7·3	80	750	55
	1	0	5·6	40	200	15·0	130	1000	43

T=Upper surface of leaf; B=Under surface of leaf (each 1 sq. cm.)

*Deposit on both sides of leaf (2 sq. cm.)

thirty times normal strength, in order to obtain appreciable quantities where cover was extremely sparse. The tracers used were Saturn Yellow as a suspension and Lissamine Flavine FFS adsorbed on 0·1% polyvinyl alcohol as a solution. Leaves, after spraying, were examined by microscope under ultra-violet light, and those falling into the following three categories of coverage were selected for examination.

(a) Very sparse : only a few isolated specks of fluorescence.
(b) Sparse : more specks than (a) but still corresponding to completely inadequate cover.
(c) Light : approaching the lower limit of effective coverage.

For examination, discs of 1 sq. cm. area were punched from representative leaves ; an estimate of the number of fluorescent particles was made and copper was determined by chemical analysis. The values obtained are shown in Table I.

The quantity of copper associated with 100 fluorescent particles at each application is shown in Table II.

TABLE II.

MICROGRAMS OF COPPER PER 100 FLUORESCENT PARTICLES.

	Tracer	Very Sparse	Sparse	Light
Mistblower ..	0·1% Lissamine	3·8	3·3	—
Atomiser ..	0·025% Saturn Yellow	19·0	6·0	3·7
	0·1% Lissamine	28·0	9·4	4·1
	0·05% Lissamine	62·0	11·0	8·6

It will be seen that in the droplet range of 25–50 microns the amount of copper associated with the fluorescent particles is greatest when the cover is most sparse. Copper was found without tracer on one occasion at the lowest level of cover. It is stressed, however, that, allowing for the high copper concentration used, the quantities of both copper and tracer involved at such levels are far too low for the practical assessment of a deposit.

The limits of visibility by eye and by the microscope were then established for some commonly used tracers for deposits of discrete droplets in the ranges 20–30, 40–60 and 50–80 microns diameter. Uniform deposits were obtained from a compressed air atomiser, made by embedding two hypodermic needles in a block of resin and connecting one to the spray fluid and the other to an air supply ; a predetermined droplet size could be obtained by using the appropriate air pressure.

The concentrations of tracer were progressively reduced to the limits of visibility ; the values are shown in Table III.

In practice, droplets smaller than 20–30 microns diameter are unlikely to be encountered during crop spraying. It has been shown that, in droplets of this size, tracer will be found associated with the active spray material. In all formulations, using tracers at or below normal field concentrations, droplets of 50–80 microns diameter are visible by eye and droplets of 20–30 microns diameter can be seen by microscope.

TABLE III.

LIMIT OF VISIBILITY ON APPLE, STRAWBERRY AND BROAD BEAN LEAVES OF SOME FLUORESCENT TRACERS.

Tracer		*Apple* Conc. (%)	*Apple* Droplet size (μ)	*Strawberry* Conc. (%)	*Strawberry* Droplet size (μ)	*Bean* Conc. (%)	*Bean* Droplet size (μ)
Saturn Yellow	Eye	0·01* 0·025†	20–30 20–30	0·025	20–30	0·01	20–30
	Microscope	0·005	20–30	0·005	20–30	0·005	20–30
Oil Colour 7G	Eye	0·005* 0·01†	50–80 50–80	0·005	50–80	0·005	50–80
	Microscope	0·005* 0·01†	20–30 20–30	0·002	20–30	0·002	20–30
Primuline	Eye	0·1	50–80	0·1	50–80	0·05	50–80
	Microscope	0·05	20–30	0·025	20–30	0·025	20–30
Lissamine	Eye	0·1	50–80	0·1	50–80	0·1	50–80
	Microscope	0·1	20–30	0·1	20–30	0·1	20–30
Fluolite	Eye	0·1	50–80	0·1	50–80	0·1	50–80
	Microscope	0·05	20–30	0·05	20–30	0·025	20–30

*Upper surface of leaf; †Lower surface of leaf.

When Saturn Yellow is used as a suspension, the tracer is apparent even though, theoretically, there is not sufficient tracer present to afford a distribution of one tracer particle per droplet. Using Saturn Yellow (particle size 4 microns) at 0·01% the ratio of particles of tracer to droplets is as follows: 20 microns = 1:57; 25 microns = 1:21; 30 microns = 1:17. In order to obtain one particle per droplet at 30 microns diameter it would be necessary, in theory, to raise the concentration of tracer to 0·17%.

THE CUTICLES OF APPLE FRUITS.

By R. F. BATT and J. T. MARTIN.

As part of the programme of work on the cuticles of plants, attention was given during the past three years to those of apple fruits. Some varieties of apple are susceptible to damage from spray treatments under certain conditions and differences are seen between varieties in their ability to withstand infection in the orchard or in storage. The behaviour of the fruits may be influenced by differences in their cuticles : apple varieties differ appreciably in waxiness and skin thickness but few quantitative data on the nature and composition of their cuticles are available.

Preliminary results of the examination of apple fruit cuticles were given in the Reports for 1957 and 1958 (1, 2). Changes in the cuticles of Merton Worcester and Cox fruits were followed during growth in 1958 (3). These investigations dealt only with the deposition of surface waxy materials and of cutin ; an examination of fruits at the end of the 1958 season indicated that appreciable quantities of waxy and other materials were embedded within the cuticles. In 1957 and 1958, in collaboration with Dr. H. B. S. Montgomery of the East Malling Research Station, analyses were made of the cuticles of Cox apple fruits grown at East Malling under different nutritional conditions. Some of the cuticle constituents differed in amount, but the results were inconclusive because of difficulties in the quantitative separation of the waxy materials. In 1959, therefore, a detailed examination was made of apple fruit cuticles to determine their nature and to obtain a dependable analytical procedure for further work on the effect of nutritional status upon cuticle formation. Cox, Crawley Beauty and Monarch fruits, which differ in waxiness, susceptibility to damage, and storage behaviour, were selected for examination. After the removal of the surface waxy deposits, the peel of the fruits was exhaustively extracted with solvents and the cutin finally determined. Tests were made in November 1959 and February 1960 ; in the interval the fruits were kept in open trays in a cold store.

Experimental.

Separation of surface waxy coverings. Ten ripe fruits, weighing individually between 110 and 148 g., were taken for analysis ; their surface areas were calculated from their mean diameters. Surface waxy materials were removed by immersing the fruits individually, with agitation, in four successive portions of chloroform at room temperature, allowing 30 seconds for each immersion. The waxy substances obtained by the successive washings were weighed ; an average of 72 per cent. of the total waxy material obtained was removed by the first immersion, 14 per cent. by the second, 8 per cent. by the third and 6 per cent. by the fourth.

After immersion, the fruits were thinly peeled, and 250 circular discs (25 from each fruit), each of 1 sq. cm. area, were taken from the peel. The fleshy material was scraped from 140 discs as cleanly as possible without damaging the cuticle ; the discs were washed with water, dried at 40°C. overnight and weighed. In the February 1960 test, ten additional discs were vigorously scraped and dried at 100°C. to obtain a more exact measurement of the weight per sq. cm. of the cuticle proper.

Solvent extraction of the skins. The 140 discs of each variety were Soxhlet-extracted with ether for 8 hr. to remove the waxy substances still present in the skins. To ascertain whether extraction was complete, a similar treatment was given using chloroform. The discs were then Soxhlet-extracted with acetone for 8 hr. ; the dried extracts obtained by these processes were weighed. Extraction was continued, using methyl alcohol, until no more pigment was removed. The discs were washed with water and refluxed with 1·6 per cent. ammonium oxalate —0·4 per cent. oxalic acid solution until the cuticular membranes separated from the cellular tissue. The membranes were collected, refluxed with 1·25 per cent. w/v sulphuric acid for 1 hr. and then with 0·2 per cent. aqueous potassium hydroxide solution, with renewal of the reagent at intervals of 1 hr., until the solution was no longer coloured. After each solvent treatment from acetone onwards, the discs (or membranes) were washed with water and dried at 100°C. to constant weight, to give a measure of the amount of material removed by each process.

Determination of cutin. The cutin was determined on the dried membranes after aqueous potash treatment by refluxing them for 3 hr. with 0·5 *N* ethyl alcoholic potassium hydroxide solution. The loss in weight on saponification gave a measure of the cutin. The remaining 100 discs of each variety were Soxhlet-extracted with methyl alcohol and the analyses continued as described above, without weighing after each solvent treatment, to give duplicate determinations of cutin. The results of the examination of the fruits are shown in Table I.

TABLE I.

ANALYSIS OF THE SKINS OF APPLE FRUITS.
(mg./sq. cm.).

Extract	November 1959			February 1960		
	Cox	Crawley	Monarch	Cox	Crawley	Monarch
Surface waxy	0·60	0·82	1·21	0·51	0·71	1·08
Ether	0·61	0·63	0·73	0·57	0·66	0·62
Chloroform	0·09	0·07	0·07	0·09	0·08	0·14
Acetone	1·60	1·29	1·86	1·26	1·38	1·05
Methyl alcohol	5·49	2·03	1·14	2·89	1·98	1·42
Oxalate	4·29	3·95	3·00	2·97	3·35	2·46
Acid-alkali	1·16	0·61	0·53	1·23	0·56	0·50
Alcoholic potash	0·75	1·06	1·04	0·68	1·02	1·06
Residue	0·29	0·09	0·11	0·25	0·12	0·14

In November, 1959, the skin of the Cox fruits, by summation of the fractions in Table I, amounted to 14·9 ; that of the Crawley fruits to 10·5 and that of the Monarch fruits to 9·7 mg./sq. cm. of surface. The average weights of 1 sq. cm. discs of skin taken after chloroform immersion of the fruits were : Cox 13·2 ; Crawley 9·6 and Monarch 7·2 mg./sq. cm. The addition to these figures of the values for the surface deposits raised the weights of 1 sq. cm. discs of Cox, Crawley and Monarch skins to 13·8, 10·4 and 8·9 mg./sq. cm. respectively. The solvent extractions reduced the skins to 1-2 per cent. of their original weights : the small amounts of residue consisted of cellulosic material.

In February 1960 the weights of skin/sq. cm. found by the summation of the fractions were : Cox 10·4 ; Crawley 9·8 and Monarch 8·5 mg. The average weights of the discs after the surface deposits were removed were : Cox 9·4 ; Crawley 9·2 and Monarch 7·1 mg./sq. cm. : on adding the weights of surface deposits, the values for the Cox, Crawley and Monarch skins were 9·9, 9·9 and 8·2 mg./sq. cm. respectively.

Fractionation of the waxy substances.

(a) *By acetone precipitation of the wax.* The surface waxy deposits and the materials obtained by ether and chloroform extractions of the skins were dissolved in acetone (4 ml. of solvent for each mg. of material) with warming ; the solutions were cooled and kept at 0°C. to precipitate the true waxes, which were filtered off, washed with cold solvent, allowed to dry at room temperature and weighed. The filtrates were made up to 100 ml. with acetone.

Aliquots (50 ml.) were taken, the solvent was removed and the residues dissolved in ether and extracted with three portions of 0·1 per cent. aqueous potassium hydroxide solution. The potash-soluble substances were recovered by acidification and extraction with ether, to yield the " acids ". The materials remaining in the ether after potash extraction, referred to as " oils ", were obtained by the removal of the solvent. The results are shown in Table II.

TABLE II.

FRACTIONATION OF SURFACE WAXY DEPOSITS BY ACETONE PRECIPITATION. (mg./sq. cm.).

Fraction	November 1959			February 1960		
	Cox	Crawley	Monarch	Cox	Crawley	Monarch
Wax	0·29	0·30	0·45	0·19	0·22	0·34
Acids	0·13	0·16	0·18	0·12	0·10	0·13
Oil	0·15	0·30	0·55	0·16	0·33	0·54

The recoveries in these fractionations were from 91 to 97 per cent. When the materials extracted from the skins by ether were examined by the same procedure, recoveries were low (60–70 per cent.) : only small amounts of wax (0·03–0·08 mg./sq. cm.) were present ; the ether-soluble acids from each variety amounted to 0·25 mg./sq. cm. and the oil varied between 0·11 and 0·15 mg./sq. cm. No wax and only small amounts of acidic and oily materials (0·03–0·04 mg./sq. cm.) occurred in the chloroform extracts of the skins.

(b) *By solvent partition.* Other work in 1959 reported elsewhere (4) led to an alternative method of fractionating the waxy materials. Acidic substances were first removed by extracting ether solutions of the waxy substances with 0·1 per cent. potash solution and the residues were resolved into the wax and oil components by partition between *n*-heptane and methyl alcohol. Recoveries near to 100 per cent. were obtained ; the wax melted sharply between 60 and 64°C, and both the acidic and oil fractions, which were white solids, at above 200°C. The results of the examination of the surface waxy deposits are shown in Table III.

TABLE III.

FRACTIONATION OF SURFACE WAXY DEPOSITS BY SOLVENT PARTITION.

(mg./sq. cm.).

Fraction	November 1959 Cox	Crawley	Monarch	February 1960 Cox	Crawley	Monarch
Wax	0·23	0·26	0·47	0·20	0·30	0·54
Acids	0·20	0·26	0·24	0·17	0·19	0·26
Oil	0·14	0·24	0·46	0·13	0·21	0·28

Solvent partition of the ether extracts of the skins in February 1960 confirmed the earlier finding that acidic substances predominated. These amounted to 41–44, wax to 24–31 and oil to 27–31 per cent. of the extracts. The materials extracted from the skins by chloroform were not examined.

Phenolic constituents. The surface waxy deposits and the ether, chloroform and acetone extracts of the skins were examined for phenolic compounds using paper chromatography. The surface deposits showed only weak reactions and the chloroform extracts gave negative results. The ether and acetone extracts of the skins contained phenolic compounds, the reactions of the acetone extracts being stronger than those of the ether extracts. The strongest spots were of quercetin glycosides ; traces of caffeic and *p*-coumaric acid derivatives were observed in the acetone and ether extracts of the Crawley Beauty and Monarch skins.

To obtain a measure of the amounts of phenolic substances present, acetone solutions of the surface waxy deposits and of the skin extracts were analysed by the procedure described for the determination of phenolic compounds in leaves (3). Quercetrin (twice crystallized from alcohol-water, m.p. 182–186°C.) was used as standard. The results are shown in Table IV.

TABLE IV.

PHENOLIC SUBSTANCES, AS QUERCETRIN, IN SURFACE WAXY DEPOSITS AND SOLVENT EXTRACTS OF THE SKINS.

(mg./sq. cm.).

Extract	November 1959 Cox	Crawley	Monarch	February 1960 Cox	Crawley	Monarch
Surface waxy	<0·01	<0·01	<0·01	<0·01	<0·01	<0·01
Ether..	0·01	0·02	0·02	0·01	0·01	0·02
Chloroform	<0·01	<0·01	<0·01	<0·01	<0·01	<0·01
Acetone	0·01	0·03	0·04	0·04	0·06	0·07

Although the levels remained low, an increase was seen in the phenolic compounds extracted by acetone after three months storage of the fruits.

Discussion.

The differentiation between the waxy materials lying on the surfaces of apple fruits and those embedded in the cuticles is no easy matter ; surface washing, even by quick immersion in solvent at room temperature, may

extract substances from within the skins. By the procedure used, however, most of the material obtained by surface washing resulted from the first immersion : in view of the additional material subsequently extracted by ether, larger amounts might have been expected from the third and fourth immersions if leaching from within the cuticles was taking place.

An attempt to obtain the relative weights per unit area of the cuticles of the three varieties, by the summation of the fractions obtained by solvent extraction, was not altogether successful because of complications introduced by the cellular tissue adhering to the discs. Most of the flesh was taken away from the 140 discs used for analysis, but the complete removal of the cellular tissue was not attempted because of the risk of damage to the cuticles. The acetone, methyl alcohol and oxalate extracts shown in Table I were high, and indicated, surprisingly, that considerable amounts of flesh remained attached to the cuticles. This was confirmed in the February 1960 tests, when individual 1 sq. cm. discs of the Cox, Crawley Beauty and Monarch skins after vigorous scraping weighed 3·8, 4·6 and 4·9 mg. ; those taken for analysis averaged 9·4, 9·2 and 7·1 mg. respectively. The cellular tissues undoubtedly contributed to the solvent extracts, but the proportions of these which came from the fleshy tissues and the cuticles proper could not be determined. An impression was gained that the Cox cuticles were more heavily loaded with non-waxy and non-cutin components than those of the other varieties, but further work is needed.

The fractionation of the surface waxy coverings gave results of considerable interest. The acetone precipitation method, as described, was unsatisfactory : wax was found to be occluded in the oil fraction, and oil contaminated the wax fraction. The solvent partition method was preferred : it gave cleaner and reproducible separations of the components.

By the acetone precipitation method, the percentages of oil in the waxy coverings of the three varieties increased during the three months storage period. Huelin & Gallop (5), using a similar acetone precipitation method, also found an increase, during storage, in the oil fraction of extracts of Granny Smith apples. Using the solvent partition method of fractionation, a different picture was obtained : the surface waxy covering of the Cox fruits remained unchanged in percentage composition over three months, but in the coverings of the Crawley Beauty and Monarch fruits the percentages of wax appeared to increase. The changes taking place in the surface coverings of the fruits during storage require further examination.

The Cox, Crawley Beauty and Monarch fruits differed appreciably in surface waxy materials and cutin. The values for these were unlikely to have been influenced by the cellular tissue ; they are brought together, for comparison, in Table V.

TABLE V.

WAXY MATERIALS AND CUTIN IN THE CUTICLES OF APPLE FRUITS.
(mg./sq. cm.).

	November 1959			February 1960		
	Cox	Crawley	Monarch	Cox	Crawley	Monarch
Surface waxy deposit ..	0·60	0·82	1·21	0·51	0·71	1·08
Cutin, on 140 discs ..	0·75	1·06	1·05	0·68	1·02	1·06
Cutin, on 100 discs ..	0·74	1·08	1·02	0·73	1·06	1·08

At both times of sampling, the Monarch fruits showed a much heavier deposition of surface waxy materials than the Cox fruits ; the Crawley Beauty fruits occupied an intermediate position. There was an indication of a falling off in the surface coverings of all three varieties after three months in storage. The Crawley Beauty and Monarch fruits showed the same high level of cutin deposition which was appreciably in excess of that on the Cox fruits ; the cutin deposit on each variety remained unchanged during storage.

More work is needed on the nature of the materials extracted from the skins after the removal of the surface waxy coverings. Ether followed by chloroform removed appreciable amounts of fatty materials but the proportions of true wax in these were low. The acetone extracts were characterized by the presence of sugars. The analytical results indicated that the true wax was deposited chiefly on the surfaces of the fruits and that the acidic materials were more deeply embedded in the skins.

Summary.

Analyses were made, by successive solvent extractions, of the skins of Cox, Crawley Beauty and Monarch apple fruits soon after harvest and after three months in storage. The Cox fruits showed less surface waxiness, and contained less cutin in their cuticles, than the Crawley Beauty and Monarch fruits. There was a slight decline in surface waxiness during storage : when tested by a solvent partition method the surface covering of the Cox fruits remained unchanged while the percentages of true wax in the coverings of the Crawley Beauty and Monarch fruits increased. Only small amounts of phenolic compounds, increasing slightly during storage, were present in the skins.

Acknowledgments.

We are indebted to Mr. A. H. Williams for the qualitative examination of the extracts for phenolic compounds.

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A NOTE ON THE POSSIBLE ORIGIN OF CROTCH CANKERS ON APPLE TREES.

By NORA M. WAUGH and R. J. W. BYRDE.

It has long been realized that there are several avenues for the invasion of apple trees by spores of the canker fungus, *Nectria galligena* Bres. Probably the most important of these is the leaf scar, which annually provides the fungus with susceptible tissue at a season when conidial production is high and climatic conditions are often suitable for infection (1, 2, 3). Such cankers are readily recognized in the field by the typical dieback produced on 1- and 2-year-old shoots by the girdling action of the canker. Pruning wounds form another obvious point of entry for the fungus, and Marsh (4) showed that during winter these may be susceptible for a period of up to two months ; again, the point of origin of the resulting canker is obvious on inspection. Other important sites of entry are wood lesions caused by other agencies, such as the apple scab fungus, *Venturia inaequalis* (Cooke) Wint. (5) and Woolly aphid, *Eriosoma lanigerum* (Hsmnn.) (6) ; if such lesions occur near cankered tissue they may be suspected as precursors of the canker fungus.

General experience, supported by observations over a number of years in Somerset orchards, has shown, however, that a type of canker frequently encountered is situated around the crotches where two main branches join, frequently at the crown of the tree (cf. 7). It is clear that spores borne in rain washings might readily accumulate in such a position, but the means of their entry has not hitherto been elucidated. The possibility that a lesion might arise from the breaking out of an old " occluded " leaf scar infection of the type described by Crowdy (3) can be discounted because of its position on the inner face of the base of a branch and not on the outer face where the initial leaf scar would have been situated.

In 1958, following a spell of very warm and humid weather from 8th-11th August (minimum temperature August 9th-10th, 57° ; maximum temperature August 10th, 76° ; dew point 10 a.m. August 10th, 65°) it was noticed that bark ruptures had developed in the crotches of a number of 6-year-old dwarf pyramid apple trees of the varieties Cox's Orange Pippin and Laxton's Fortune on M.II rootstock growing vigorously in grass (see Plate VIII, Fig. 1). It seemed that these ruptures might provide a possible entry for spores of *N. galligena* and thus give rise to crotch cankers. Specimens were therefore collected and taken to the laboratory for an examination of the morphological changes. Observations were continued during the remainder of 1958 and 1959.

The method used for sectioning and staining was based on that of Crowdy (8) : the tissue was cut to suitable size, boiled in distilled water, softened for 12–24 hr. in methylated spirits and glycerine (equal parts) and sectioned (without embedding) on a freezing microtome. Sections were mounted on slides with Gravis (mixture of 0·1% aqueous agar and 0·1% aqueous camphor) and collodion and stained with safranin and picro-aniline-blue.

Fig. 3 shows in diagrammatic form a longitudinal section through a crotch in mid-August, 1958, cut in the plane of the main axis and branch. It was apparent that the original cork cambium had proliferated to produce a large meristematic area (shown by a circle in the diagram), from which a new

Fig. 1. Rupturing of bark in the crotch of a dwarf pyramid apple tree ; mid-August 1958. The rectangle denotes the limits of the longitudinal sections shown in Figs. 3 and 4.

Fig. 2. Crotch canker ; July, 1959.

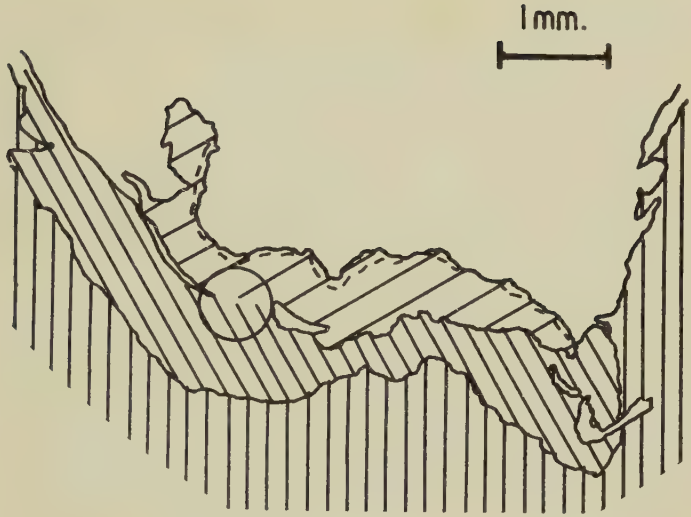


Fig. 3. Diagram of longitudinal section through crotch with ruptured bark ; mid-August 1958. The diagram corresponds to the rectangle in Plate VIII, Fig. 1.

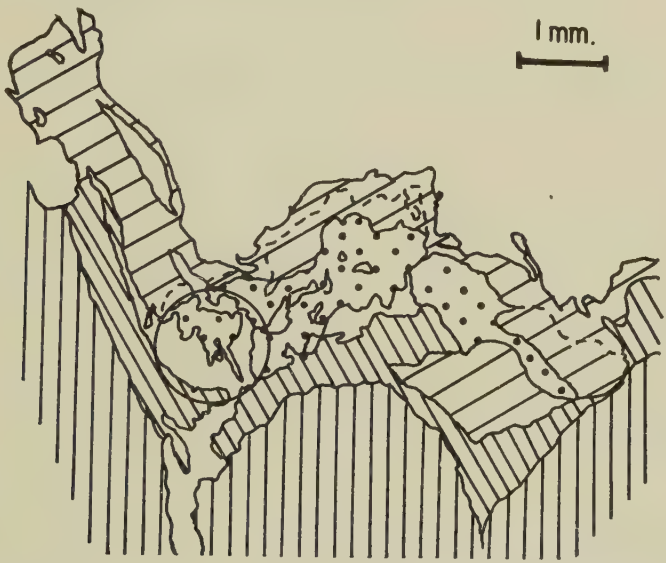
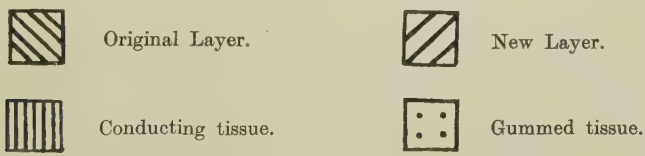


Fig. 4. Diagram of longitudinal section of similar crotch ; early March, 1959.



outer layer had been formed, consisting mainly of parenchymatous cells (indicated as the area within the broken line). At this stage the bark layer was extremely thin. The speed of tissue development had apparently been so rapid as to leave ruptures in the surface, well illustrated in Plate VIII, Fig. 1.

Further specimens were collected in early March, 1959 : a longitudinal section of a typical crotch is shown diagrammatically in Fig. 4, again with the main axis on the left. Comparison with Fig. 3 shows the new layer more developed, with thicker bark tissue (outside broken line), but still some undifferentiated parenchyma. There was extensive gumming between the old and new layers, suggesting the presence of an infection, and in some of the sections fungal hyphae were present.

Observations in the orchard during the 1959 growing season showed that cankers had developed on some of the crotches that had produced the proliferating tissue described above. Plate VIII, Fig. 2, shows a typical example. During the winter of 1959-60, perithecia of *N. galligena* were observed on 11 of the crotch cankers, whilst from one of the cankered areas not bearing perithecia, *Gloeosporium perennans* Zeller and Childs, the perennial canker and bitter rot fungus, was isolated by culture on 2% malt agar and kindly identified by Dr. A. T. K. Corke.

It would thus appear that the familiar crotch canker may arise from injury induced by excessive meristematic activity, followed by rupture of the bark. Whilst fresh bark tissue is fairly soon regenerated, fissures are formed which persist throughout the winter and tend to become waterlogged. With the tendency of waterborne spores to accumulate at branch junctions, the liability to canker infection becomes obvious. Once established, such a canker is well placed to girdle the side branch or even the main stem of the tree (7).

In contrast to leaf scar infections and pruning wounds, such injury seems likely to arise only during the summer months. High temperature coupled with high humidity may well lead to a rapid uptake of water from the soil, without appreciable transpiration loss to counter-balance it. It was significant that no such crotch injuries were observed on these or other trees during 1959, when high summer temperatures were accompanied by lower humidity, and the soil was generally dry.

Acknowledgment.

We wish to thank Mr. D. E. Aliband for the two photographs.

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THE EFFECT OF DINITRO-*ORTHO*-CRESOL ON APPLE BUDS IN RELATION TO THE CONTROL OF MILDEW.

By NORA M. WAUGH.

The work described below arose out of an experiment at Luddington Experimental Horticulture Station in which trees of Cox and Worcester sprayed in mid-March with 0·1% dinitrocresol in 3% spindle oil have been compared yearly since 1953 with others receiving no DNC spray. This comparison is made on trees further classified into three groups according to their respective summer spray treatments : (i) normal lime sulphur, (ii) weak lime sulphur, (iii) captan. In 1957 it was noted that the Cox trees receiving DNC showed less primary mildew than the comparable trees receiving no DNC (1). In the following year this difference was more marked (2) : on the captan plots there was 2·3% primary mildew on the DNC-sprayed Cox trees compared with 5·6% on those not receiving DNC ; on the lime sulphur plots the DNC reduced primary mildew from 0·8% to 0·1%.

In 1958 Moore and Bennett similarly showed (4) that in a five-year trial at East Malling an early-spring application of DNC consistently reduced primary mildew on Cox.

Work was carried out at Long Ashton in 1958-59 to examine the mode of operation of DNC in controlling mildew on leaf buds on extension shoots of apple and to determine whether the effect was modified by the time of treatment and by the condition of the buds.

Materials and Methods.

The commercial DNC preparation employed was a spindle oil emulsion containing 3·3% w/v dinitro-*ortho*-cresol. This was diluted to give a wash containing 0·1% DNC and 3% oil.

The trees used were 24-year-old Cox's Orange Pippin bush trees in grass, on which, in October 1958, 25 shoots were selected bearing apparently only healthy buds (set A), and 50 shoots bearing obviously mildewed buds (set B). Half of each set was left untreated ; the other half was divided into five groups treated respectively in November, December, January, February and March by dipping the shoots, without removal from the tree, in diluted DNC wash contained in a measuring cylinder.

A few buds were removed in December, February and April for sectioning. The remainder (about 85% of the total) were left *in situ* until May, when they were classified into three categories : healthy, mildewed but alive, and dead.

Results.

Table 1, which gives the results of the May counts, shows that, in the apparently healthy set A, 2 of the 59 untreated buds and 2 of the 76 treated buds developed mildew. The March DNC treatment greatly increased the proportion of dead buds in comparison with that in the untreated controls. Some killing was also recorded in buds treated in November and in February.

TABLE I.

EFFECT OF DNC ON BUDS OF COX'S ORANGE PIPPIN : COUNTS IN MAY 1959.

		Healthy	Dead	Mildewed
Set A.	*Buds apparently healthy in Autumn* 1958			
	(i) DNC-treated on Nov. 14	8	5	0
	Dec. 16	14	0	0
	Jan. 16	15	0	0
	Feb. 16	12	3	2
	Mar. 17	5	12	0
	(ii) Untreated	49	8	2
Set B.	*Buds mildew-infected in Autumn* 1958			
	(i) DNC-treated on Nov. 14	8	7	0
	Dec. 16	8	8	1
	Jan. 16	10	16	2
	Feb. 16	21	39	2
	Mar. 17	13	42	0
	(ii) Untreated	25	115	60

In set B (buds obviously mildewed at the beginning of the experiment) there is an indication of some dying-out of infection during the winter, as suggested by Burchill (3). Thus, of the 200 untreated buds, 25 were healthy in May, 60 were mildewed but alive, and 115 dead, presumably killed chiefly by mildew. In contrast, of the 55 buds treated with DNC in March, 13 were healthy, 0 mildewed and 42 dead. The earlier treatments gave a lower proportion of deaths and a little mildew.

Sectioning of the buds collected throughout the period of the experiment demonstrated an incomplete closing of the scales of buds severely infected with mildew ; by mid-March the scales of healthy buds were also starting to separate.

Discussion.

The results confirm that March treatment with DNC-oil reduces the number of primary outbreaks of mildew and show that this effect, already established for blossom buds, occurs also on vegetative buds. In the group of mildew-infected buds treated in March with DNC, three-quarters were killed and the rest showed no mildew in May : the comparable untreated buds showed 58% deaths and 30% mildew. It therefore appears that the DNC treatment in March results in the outright killing of mildewed buds that might otherwise have survived to produce primary infections ; the examination of sectioned buds provided no evidence of killing of overwintered mildew unaccompanied by death of the bud tissue. These sectioned buds did, however, show that mildew infection was often associated with incomplete closure of the bud scales ; this probably facilitated the penetration of the DNC and consequent killing of the bud. The results of the DNC treatment of mildew-infected buds in December, January and February indicate a similar, although less drastic effect of the DNC in these earlier applications.

In the group of healthy buds (set A), two-thirds of those treated with DNC-oil in March were also killed : it is probable that this phytotoxic effect was unusually serious because of the early bud-burst in 1959, approximately 3 weeks in advance of normal. The degree of phytotoxicity to be expected

from a March DNC spray in a normal season would probably be more fairly indicated by the mortality (20%) recorded in 1959 for the February-treated healthy buds. Provided that the phytotoxicity of an early spring application of DNC in a normal season were low, such a treatment would have value as an ancillary measure in mildew control, but its effects could not be expected to be as important as those of the summer spraying programme.

Summary.

Spraying of apple trees in the late-dormant stage with 0·1% DNC in 3% spindle oil reduced the spring outbreak of primary mildew infections.

There is evidence that the mode of action of the DNC on extension shoots is the killing of mildewed buds that might otherwise have survived to produce infected leaf trusses.

In the 1959 season, when bud-burst was exceptionally early, the DNC-oil spray in mid-March caused considerable damage to healthy buds.

Acknowledgment.

I wish to thank Mr. R. W. Marsh for his help and interest in this work.

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BLACK CURRANT LEAF SPOT: TREATMENT OF OVERWINTERED LEAVES WITH FUNGICIDES: SUMMARY OF EXPERIMENTS, 1953-59.

By A. T. K. CORKE.

Up to 1952, experiments carried out at Long Ashton on the control of black currant leaf spot aimed at preventing the spread of the disease on the leaves during the late spring and summer. With the confirmation, in the winter of 1952-53, of the widespread occurrence of the perfect stage of the fungus (*Pseudopeziza ribis*) on dead leaves in the plantations at Long Ashton, work was directed towards eradicating the fungus during the winter. The methods and some of the materials used have already been described (1, 2). In the following paper the results obtained over six winters are summarized, and observations on the biology of the fungus are discussed in relation to the whole problem of control.

Experimental.

Laboratory tests of fungicides.

The treatment of dead leaves, and the effect of treatments up to the spring of 1956, have been described elsewhere (1, 2). In the following three winters the treatments were carried out on 21st February, 1957 (Trial 5), 24th October, 1957 (Trial 6), 22nd January, 1958 (Trial 6a) and 6th February, 1959 (Trial 7).

In Trial 5, aqueous solutions of four materials were used, each at the same four concentrations: 0·1, 0·5, 0·025 and 0·0125 per cent.

(a) Sodium salt of dinitro-*ortho*-cresol (commercially prepared sample containing approximately 50% DNOC).
(b) Sodium salt of dinitro-*ortho*-cresol freshly prepared from DNOC (90% pure) and sodium hydroxide.
(c) Ammonium salt of dinitro-*ortho*-cresol freshly prepared from DNOC (90% pure) and ammonium hydroxide.
(d) Sodium pentachlorophenate (sodium PCP).

Treatment with ammonium DNOC was omitted from Trial 6 with leaves which were still half green, and from Trials 6a and 7 with overwintering dead leaves. Freshly prepared sodium DNOC (b) was used in Trial 6a at 1·0 and 0·05 per cent, a new consignment of DNOC being used in the preparation. In Trial 7, ammonium DNOC was replaced by *n*-dodecyl-guanidine acetate (65% wettable powder) used at the same concentrations as the other materials.

A number of small trials were also carried out:

(8) On 28th October, 1954, dead and half-green leaves were dipped in colloidal copper solutions containing 0·375% or 1·125% copper.
(9) On 13th April, 1955, both wet and dry leaves were immersed in a 0·4% solution of sodium arsenite with a wetter (0·25% Estol H).
(10) Dead, and green infected leaves were collected on 10th August, 1955, and immersed in colloidal copper solutions as in (8) above; half were subsequently dipped in 0·0125% DNOC in 3% diesel oil on 8th February, 1956.

(11) Aqueous solutions of copper sulphate and Cheshunt mixture containing 0·8% and 0·4% copper were used to treat dead leaves on 22nd January, 1958.

(12) On 31st October, 1957, as a corollary to the treatment of detached leaves (Trial 6), the same materials (sodium DNOC of two types and sodium PCP) were used to soak thoroughly a number of lightly infected Baldwin bushes (in pots) while still in leaf. The concentrations were 0·1% and 0·025%; after drying, the plants were placed outside in ashes for the winter.

TABLE I.

DISCHARGE OF ASCOSPORES OF *P. RIBIS* AFTER LABORATORY TREATMENT OF OVERWINTERING INFECTED LEAVES WITH FUNGICIDAL MATERIALS.

Trial Number	Material used	Concentration (% active material) 0·1	0·05	0·025	0·0125	0·00625	Control
1		0	0				67
2	Sodium	0		1		2	3
3	DNOC	0	0	0	7	4	2
4	(commercial	0	0	0	2	14	26
5	sample)	16	9	67	46		72
6		0	7	13	10		12
7		0	0	0	0		1
	Means	2·3	2·7	13·5	13·0	6·7	26·1
4		0	0	0	0		16
5	Sodium	1	12	63	32		56
6	DNOC	0	4	25	21		18
6a	(freshly	0	0				
7	prepared)	0	0	0	0		0
	Means	0·2	3·2	22	13·3		22·5
4	Ammonium DNOC	0	0	0	15		14
5	(freshly prepared)	34	22	64	40		64
	Means	17	11	32	27·5		39
1		0					53
2			1		11		3
3	Sodium	0	0	6	2		0
4	pentachlorophenate	0	1	11	21		23
5		0	4	32	39		95
6		0	4	12	17		9
7		0	0	1	1		2
	Means	0	1·7	12·4	15·2		26·4
1		0					3
2	DNOC in 3%	0					—
3	diesel oil	0	0	0	0		19
4		0	0	0	0		—
	Means	0	0	0	0		11

TABLE II.

DISCHARGE OF ASCOSPORES OF *P. RIBIS* AFTER LABORATORY TREATMENT OF OVERWINTERING INFECTED LEAVES WITH FUNGICIDAL MATERIALS.

Trial Number	Material used	Concentration (% active material) 0·4	0·2	0·1	0·05	0·025	0·0125	Control
1	PMC	0	0	0	0			86
1	Triethyl tin hydroxide	0	0	1	19			99
1	Cetyl pyridinium bromide	4	1	24	46			65
7	*n*-Dodecyl-guanidine acetate			2	1	0	7	3
9	Sodium arsenite	0						7·2*
		0·8	0·4					
11	Copper sulphate	2	5					1 } 10*
11	Cheshunt mixture	2	3					1 }
		1·125	0·375					
8	Colloidal copper							
	Dead leaves	11	2					7·2*
	Green leaves	9	14					
10	Colloidal copper + DNOC(0·125%)							
	Dead leaves	0	0					
	Green leaves	0	0					
	Colloidal copper							
	Dead leaves	0	0					0 } 21·5*
	Green leaves	0	0					

* Mean of control figures for year concerned. (*See* text).

Results.

Since ascospores of *Pseudopeziza ribis* are discharged in the spring from untreated, infected leaves, assessment of the effect of treatment was made by determining, microscopically, the density of the spore deposit from discs (1 cm. diam.) bearing apothecia cut from treated leaves. The density observed was compared with prepared diagrams showing 25, 50 and 75 spores per unit area : up to 25 spores was rated as 1, and over 75 spores as 4. The area covered by the densest deposit was also rated from 1 (small) to 3 (large), and the product of the two figures (maximum 12) taken as a measure of spore discharge from each disc. The totals for ten leaf discs from each major treatment, together with those for the controls with each treatment, are given in Table I : the results of the first four trials (1953-56) are also included, except for those in which the materials were used at concentrations of 0·2 per cent and above, when inhibition of ascospore discharge was complete in every case.

The results of trials with other materials used on only one occasion are given in Table II. Since individual controls were not included in all these smaller trials, the mean of the control figures obtained in the major treatments in the year concerned is given and marked with an asterisk.

Leaves used in these trials were all from infected bushes of the variety Baldwin and, with the exception of Trial 10, were gathered between 20th October and 20th November in each year.

It will be seen that spore discharge from untreated leaves varied widely from year to year but, except in Trial 5, inhibition was complete after treatment

with the materials used in these trials, at a concentration of 0·1%. A considerable reduction in spore discharge also followed treatment with 0·05% sodium PCP and DNOC in all the forms used, while DNOC in 3% diesel oil gave the most consistent results at all concentrations (Table I). Although the ineffectiveness of treatments other than sodium PCP in Trial 5 suggested a deterioration of the DNOC used, the commercially prepared material used throughout to prepare sodium DNOC also showed a reduced effect on this occasion. It seems possible that there was some biological reason for the failure to inhibit sporulation in the winter of 1956-57.

The treatment of bushes with fungicidal materials (Trial 12) in 1957 showed no effect in the following spring on flowering, foliation or fruiting. The fruit was picked on 31st July and canned; no taint was found when tasted by the tasting panel after being stored for six months at room temperature. Unfortunately, too few leaves were available for the ultimate effect on leaf spot to be assessed.

Discussion.

It seems clear, from the results of the experiments described above, that the discharge of ascospores from overwintered black currant leaves infected with *Pseudopeziza ribis* can, under laboratory conditions, be effectively reduced by brief immersion in a fungicidal material in winter. A number of materials were effective at 0·1% in the laboratory, but it has already been reported that a field trial with one of the best of them, 0·1% DNOC in 3% diesel oil, gave poor results. This was thought to be due mainly to inadequate cover, since this material had been found to be effective against *P. ribis* when applied to either surface of both wet and dry leaves (1). It was therefore suggested that the application of one of these tested materials before leaf-fall might overcome this difficulty, by reaching the leaves before they became aggregated on the soil. While a pilot trial (Trial 12) showed that there appeared to be no adverse effects on bushes so treated, or on the fruit picked and canned, during the following year, a field trial has not been possible. Nor has it been possible to assess the effect of these treatments on infection by *P. ribis* in succeeding years.

Early work at Long Ashton by Marsh (3) had established the value of pre- and post-cropping sprays, with a number of fungicidal materials, in delaying defoliation due to this fungus and in increasing the cropping power and vigour of the bushes in the following year. There was no record, however, of any subsequent reduction in leaf spot infection due to inactivation of the inoculum. Experiments described here (Trials 8 and 11) have shown that the application of copper alone to fallen overwintering leaves in late October or January has no effect on the maturation of the apothecia.

From observations on the fungus, it appears that only leaves on which the fungus has reached a particular stage in its development at a certain time of the year will carry the fungus through the winter on the ground. The implication is that the initiation of the perfect stage is dependent on environment : either the external conditions, or the physiological state of the host, or both. Thus it might be advantageous to apply an extra post-cropping spray or an eradicant spray before leaf-fall, with the object of disrupting the normal development of the fungus at this time. This has already been suggested as a possible method of obtaining adequate cover of the overwintering leaves.

There remains the problem of reaching the lower surfaces of infected leaves, where the vital processes concerned in the further development of the fungus appear to take place. This might be achieved by a different method of applying the spray, or by the selection of a material that would penetrate the leaf from the upper surface, either directly, or through the infected areas.

Current trials of materials having some of the desirable qualities, taking into account the problems of residue, toxicity, timing and rates of application, have so far given encouraging results. The object is to select a single material which, applied at several specific times in the first year of infection, will reduce leaf spot to such an extent that only an occasional spray will subsequently be needed to maintain complete control of this disease.

Summary.

During the winters of 1953-58 brief immersion in fungicidal materials, in the laboratory, of overwintering leaves infected with *Pseudopeziza ribis* effectively reduced the subsequent discharge of ascospores. Observations suggested that only some of the infected leaves carried the fungus through the winter on the ground. The value of an eradicant spray before leaf-fall is discussed.

Acknowledgments.

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A SPRAYING TRIAL AGAINST STRAWBERRY GREY MOULD *(BOTRYTIS CINEREA).*

By M. A. RASHID KHAN.*

Losses by fungus rotting of strawberry fruits in the field are usually due to grey mould (*Botrytis cinerea*) or powdery mildew (*Sphaerotheca humuli*). Both diseases may be present in a strawberry crop in the same season, but usually one or the other predominates. It has been established (4, 5, 6) that attacks of grey mould on the varieties Royal Sovereign and Auchincruive Climax can be checked by spraying with thiram and captan. Sorbic acid at 0·025%, used in the U.S.A. as a food preservative, inhibits the growth of *Botrytis cinerea* on strawberry purée at pH 4 (1). Another fungicide of current interest is dodine (*n*-dodecyl-guanidine acetate : Cyprex) which has not hitherto been specifically tested against *Botrytis cinerea* but has been stated to control peach storage rots (2).

The other common disease of strawberry fruits—powdery mildew—has been successfully controlled on the variety Royal Sovereign by dinitrocaprylphenyl crotonate (Karathane) (3) and partially controlled by griseofulvin (8). In a trial at Luddington Experimental Horticulture Station against mildew (3), incidental records were made of *Botrytis* attack and it was noted that there was a marked reduction following Karathane applications but little effect from a 0·1% spray of a 50% wettable powder preparation of griseofulvin. However, griseofulvin has been reported (7) to give successful control of *Botrytis cinerea* on lettuce.

The experiment described below was designed to establish the relative field performances of the four fungicides, dodine, griseofulvin, Karathane and sorbic acid against grey mould of strawberry. The trial was made on the variety Talisman to obtain information on the sensitivity of this newly-introduced variety to spray damage.

Materials and Methods.

Plots. The plants used were in the SE corner of Plot 12 at Long Ashton Research Station and comprised 432 three-year-old Talisman plants set out in 12 rows of 36. The rows were 2 yd. apart, with 1 ft. 6 in. between plants. The area was divided into 18 experimental plots each of 4 rows of 6 plants, the outer rows of each plot serving as guards. The 18 plots formed three blocks, each of 6 plots over which the four fungicide treatments and two identical controls were randomized.

Fungicides. The materials and concentrations were :

(a)	Karathane (as wettable powder containing 25% dinitrocaprylphenyl crotonate)	12 oz./100 gal.
(b)	Sorbic acid	1 lb./100 gal.
(c)	Griseofulvin (as 50% wettable powder)	2½ lb./100 gal.
(d)	Dodine (as wettable powder containing 50% *n*-dodecylguanidine acetate)	12 oz./100 gal.
(e) and (f)	Unsprayed controls.	

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The work reported in this paper was done at the Long Ashton Research Station in partial fufilment of the requirements of the University of Bristol Diploma in Plant Pathology and Protection.

All materials were applied with a small hand-sprayer, approximately 3 gal. being used on each plot at each time of spraying.

Times of application. Sprays were applied on 6 May, 15 May, 25 May and 12 June. The first spraying was done when 3-4 flowers per plant had opened and the last when about one-quarter of the fruits were beginning to show a pink colour. All treatments were made on calm days when spray drift was negligible.

Rainfall in May was 1·68 in.; in June 1·74 in. (approximately 70% of normal for the two-month period): sunshine and temperature were above average.

Results.

Phytotoxicity. Except for Karathane, none of the fungicides caused any damage to the plants. After the first spraying, the plots treated with Karathane showed a scattered flecking of the leaves with small necrotic spots, but this had no effect on the vigour of the plants, and in the subsequent sprayings no such damage occurred. No damage or disfigurement of the fruit resulted from any spray and no alteration in the flavour of the fresh fruits was noted. Processing trials were made only with Karathane-sprayed strawberries; these showed no taint in canned or quick-frozen fruit.

Yields. Yields are given in Table I: no significant differences resulting from treatments were established.

Control of Botrytis *infection.* Infection of fruits by *Botrytis* was first noted on 12 June. Picking was done on 18, 22, 24, 26 and 30 June and at each pick all the fully-ripe, diseased and damaged fruits were harvested and weighed, and the total number of *Botrytis*-infected fruits per plot was recorded. The number of *Botrytis*-attacked fruit per lb. for each time of picking and each treatment is shown graphically in Fig. 1. A summary of the results over the whole picking season is given in Table I.

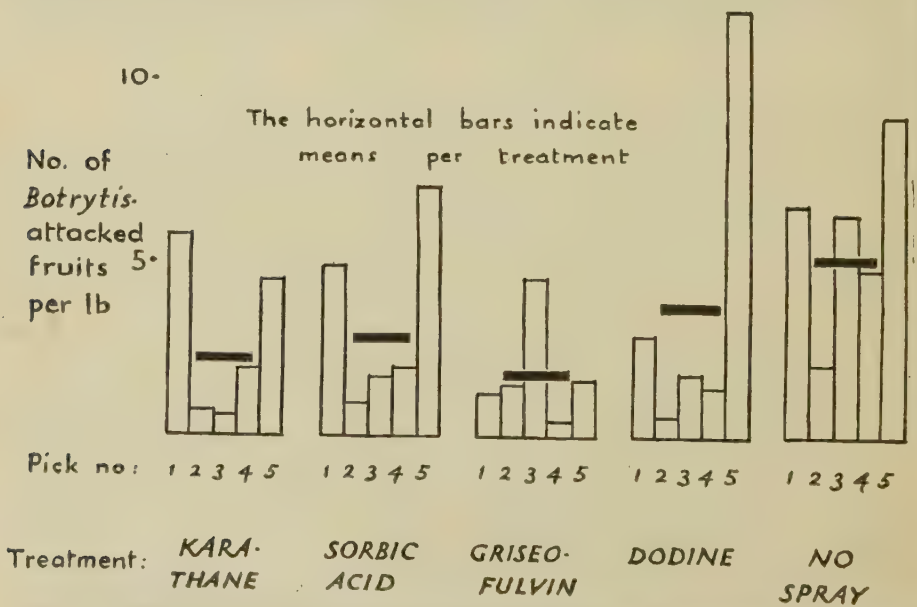

Fig. 1. *Botrytis* infection of strawberries in relation to time of picking and spray treatment.

TABLE I.

TOTAL YIELDS OF FRUITS AND NUMBERS OF *BOTRYTIS*-AFFECTED FRUITS PER LB.

Treatment	Total yield per treatment (lb.)	Mean number *Botrytis*-attacked fruit per lb.
(a) Karathane	54·5	2·11
(b) Sorbic acid	52·5	3·01
(c) Griseofulvin	46·9	1·67
(d) Dodine	42·5	3·74
(e) Control	44·9	5·21
(f) Control	45·9	
Significant difference at $P=0·05$		2·80
$=0·01$		3·95

Fig. 1 shows that, in all treatments, the *Botrytis* infection at the fifth pick was much greater than that at the fourth. This was specially marked in the dodine-treated plots, where the over-all poor record of dodine is attributable to its failure to control the disease in the final picking.

In the relatively dry season, the attack of *Botrytis*, even on the unsprayed plots, did not attain serious proportions, but the results were adequate to establish significant disease reduction by two of the spray treatments. The differences from the controls were at the 5% level of significance for griseofulvin and Karathane : the *Botrytis* attack on the plots sprayed either with dodine or with sorbic acid was not significantly different from that on the unsprayed plots.

Discussion.

Throughout the experiment no powdery mildew infection of the fruit appeared, so the trial afforded an opportunity of judging the effects of sprays on *Botrytis* rots uncomplicated by the presence of mildew. In the present trial the effect of Karathane in checking *Botrytis* on strawberries is confirmed, and the use of griseofulvin, at $2\frac{1}{2}$ times the strength employed by Ingram *et al.* (3), is shown to be equally efficacious. None of the materials tested gave as good control as that usually obtained with thiram or captan.

No phytotoxic effect of any importance was recorded with any of the four fungicides tested and they had no deleterious effect on fruit appearance or flavour.

Summary.

In a spraying trial made on the strawberry variety Talisman against *Botrytis* rot of the fruit it was found that a significant degree of control of the disease was given both by griseofulvin and Karathane. Dodine and sorbic acid failed to control *Botrytis* in this trial.

Acknowledgments.

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A SIMPLE SUCTION APPARATUS FOR THE UNIFORM DEPOSITION OF DRY FUNGAL SPORES ON DETACHED LEAVES.

By N. G. MORGAN.

Introduction.

A preliminary account (1) has been given of a laboratory technique, using *Botrytis fabae* on detached leaflets of the broad bean, for the biological assessment of fungicide spray deposits. The technique consists of the uniform mass-inoculation with fungus spores of the leaflets bearing the spray deposits, and the subsequent use of the lesion distribution on treated and untreated portions to assess the biological efficacy of the fungicide deposits.

Early experiments with this technique showed that the manner in which the spores arrived on the leaf, and the moisture status at the time of germination, had a profound effect upon the efficiency of the small separate fungicide deposits produced by some methods of small-volume spraying. For instance, the area of protection afforded by a standard pattern of deposits on the leaflet was much greater if the spore suspension were applied as a complete film than if it were applied as small discrete droplets.

Since the spores of some fungi arrive on the foliage in the dry state it was also considered desirable to investigate the efficiency of fungicide spray deposits under these conditions. It was found that dry *Botrytis fabae* spores, applied to the leaflets with an artist's brush, germinated in the absence of extraneous water, provided that the leaflets were incubated in an atmosphere with a relative humidity above 70% ; the germination rate increased with relative humidity to a maximum at 95%. The dry spores failed to germinate on dry glass slides in the same atmosphere, and it was concluded that they were then unable to absorb sufficient moisture for germination direct from the air, but could do so when in contact with the leaflet surface.

In all cases in which the biological effect of fungicide distribution is being studied, uniform distribution of the spores over the leaf surface is essential. Spores in a water suspension can be satisfactorily distributed by a standardized spraying technique using a calibrated compressed-air spray gun, but no method of distributing dry spores appears to have been published. The apparatus described below was therefore devised to collect fungus spores by suction from pure cultures and to distribute them uniformly over leaf surfaces.

Apparatus.

Fig. 1 illustrates the apparatus and method of use, employing bean leaflets and dry spores of *Botrytis fabae*.

The detached bean leaflets to be inoculated are laid as flat as possible, with their under-surfaces uppermost, on the aluminium sheet within a marked circle of a diameter corresponding to the internal diameter of the bell-jar. The bell-jar, with the inlet tube at the top and the outlet at the side near the base, is placed over the leaflets so that its outer rim registers with a second marked circle concentric with the first. The inlet is connected by pressure-tubing to the spore suction tube, which is specially shaped to facilitate manipulation inside the spore culture bottles. Loss of spores through the outlet is reduced by a muslin filter. The other end of the outlet is connected by pressure-tubing to the suction pump, which may be water-or electrically-operated. If a bell-jar with a tubulure at the side is unobtainable, a standard jar is easily adapted by arranging an outlet tube to extend from the top to the side near the base.

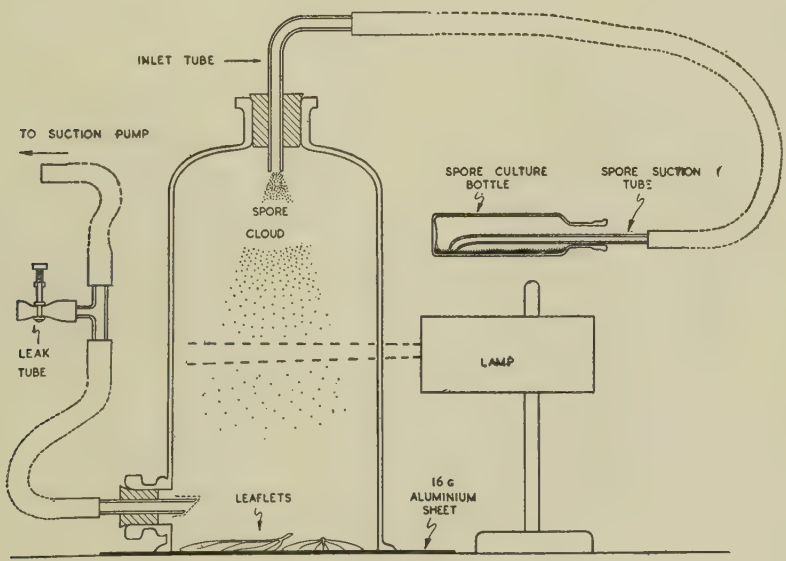


Fig. 1. Dry spore suction apparatus.

When suction is applied, air is drawn through the spore suction tube and passes from the spore culture bottle into the bell-jar. The vacuum in the bell-jar is adjusted by the leak-tube and clip on the outlet side of the system.

Sufficient vacuum for operation is indicated by the aluminium sheet adhering to the base of the bell-jar when this is lifted from the bench. Vaseline or other sealing-agent is not needed on the ground base of the bell-jar ; it would, in fact, nullify the above test.

The spore suction tube is a 14 cm. length of 4.5 mm. bore glass tubing bent at right angles and cut off as close to the bend as possible. The end is then ground parallel to the main portion of the tube. The area of the aperture is approximately 13 sq. mm. and, with 6 mm. bore tubing throughout the remainder of the apparatus, sufficient vacuum for operation is 10–15 mm. mercury, measured in the bell-jar.

When leaflets are in position and the apparatus has been tested, the spore suction tube is inserted into the culture bottle and the sporing surface of the fungus mat lightly touched. Large numbers of spores are drawn into the bell-jar and form a cloud which can be observed with the aid of a narrow beam of intense light, such as that produced by a focusing microscope lamp, and a dark background outside the bell-jar. As soon as the cloud appears the suction is cut off and the spores are allowed to settle on the leaflets by gravity. From 12 to 15 minutes are required for all the spores to settle, but most will have done so within 3–5 minutes. The only operations necessary for successive inoculations are replacement of the leaflets, operation of the suction pump and the application of the suction tube to the spore culture. The apparatus should be cleaned periodically with alcohol to remove spores adhering to the suction and inlet tubes, bell-jar and the aluminium sheet.

With the construction and operation of the apparatus thus standardized, the deposition of spores over the area covered by the bell-jar is sufficiently uniform for most purposes, particularly if the number of spores required per unit area is high, though particular applications may require modification of the inlet tube to provide greater uniformity.

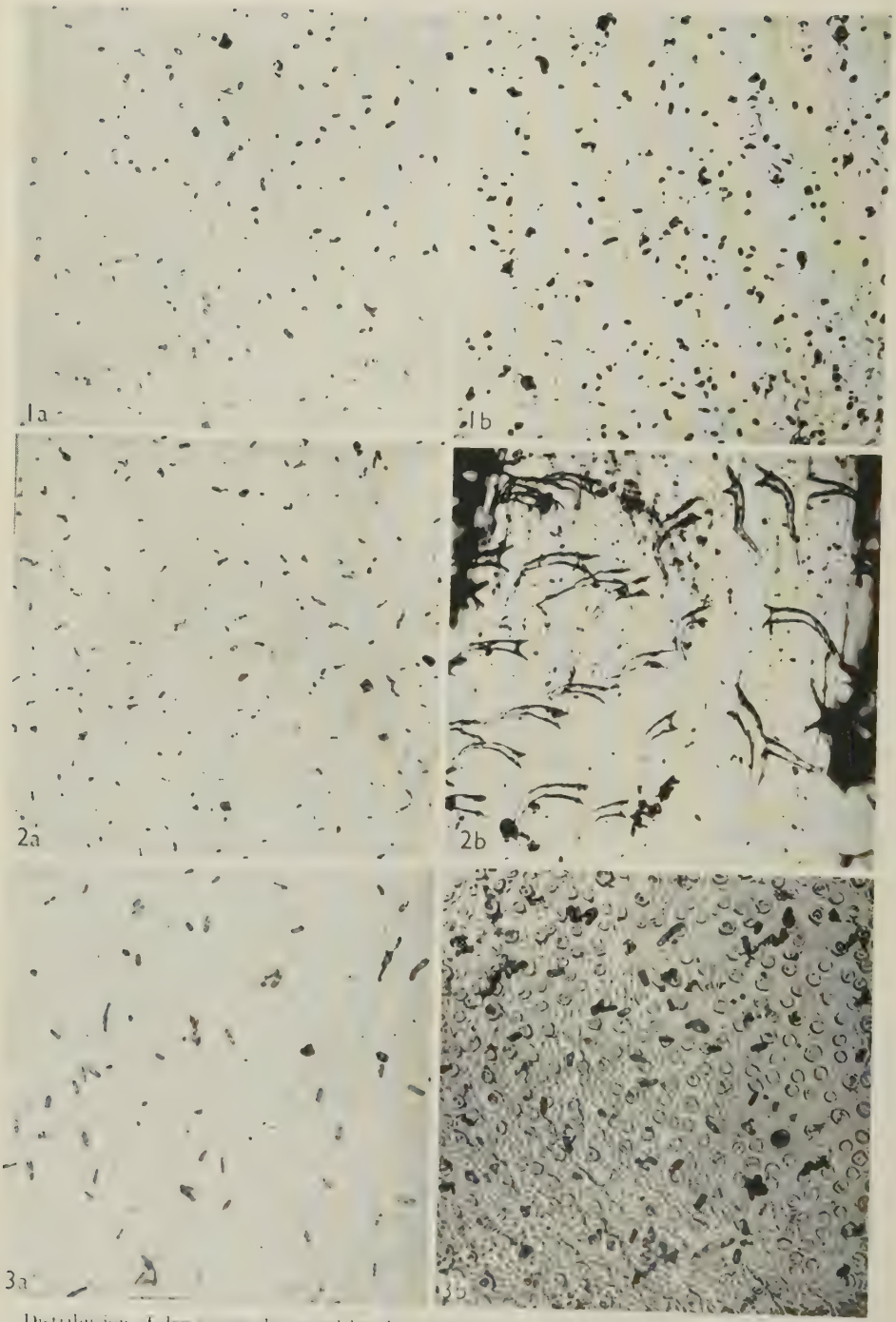
Provided that spore cultures have been produced under standardized conditions, the required spore number and subsequent lesion density can be selected by varying the number of probes of the suction tube over the sporing surface in the culture bottles. One ' probe ' is the firm application of the end of the tube vertically to the sporing surface and its rapid release ; the tube end is in contact for about $\frac{1}{2}$ second. The surface area from which the spores have been removed appears as a dark patch slightly larger than the end of the tube, the spores having been removed from the area beneath the tube walls as well as that beneath the aperture. The end of a tube of 4·5 mm. bore and 6·5 mm. O.D., if undistorted, removes spores from approximately 45 sq. mm. of the culture mat. In practice, however, the distortion of the tube caused by bending reduces this to approximately 30 sq. mm.

Further adjustments to lesion density may be made by varying the time of exposure of the leaflets to the settling spores. The effects of the number of probes and spore settling times upon lesion density are shown in Plate IX.

The apparatus has so far been mainly used for the deposition of dry spores of *Botrytis fabae* on broad bean leaflets from standardized cultures, but Burchill (2) has successfully used it for the inoculation of apple leaves with spores of apple mildew, *Podosphaera leucotricha*, by passing the suction tube over conidiophores on infected leaves. The apparatus has similarly been used by Roberts (3) for the inoculation of *Euonymus japonicus* leaves with spores of

PLATE IX.

Effect of number of probes and settling times of dry *Botrytis fabae* spores on lesion density.
(a) 1 probe for 30 seconds ; (b) 1 probe for 3 minutes ; (c) 2 probes for 3 minutes ;
(d) 1 culture bottle length (7·0 cm.) for 3 minutes.



Distribution of dry spores deposited by the suction apparatus (a) on glass slides (b) on leaf surfaces (cellulose acetate impressions).

Fig. 1. *Botrytis fabae ;* (b) on broad bean leaf.
Fig. 2. *Cladosporium fulvum ;* (b) on tomato leaf.
Fig. 3. *Oidium euonymi-japonicae ;* (b) on Euonymus leaf.

Oidium euonymi-japonicae and those of tomato with spores of *Cladosporium fulvum*. Plate X shows the distribution of spores obtained with the apparatus on glass slides and on leaf surfaces.

The apparatus has also been used for the preparation of spore suspensions direct from cultures by extending the inlet tube, immersing the end of this in distilled water and allowing the spore-laden air to bubble through it.

A further use of the apparatus is the mass inoculation of malt agar plates with dry spores of *Cladosporium fulvum*. The plates so inoculated are rapidly covered with the fungus, and the resultant spores are of more uniform age than is obtainable with a single point inoculation.

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THE BEHAVIOUR OF THE BLACK CURRANT GALL MITE (*PHYTOPTUS RIBIS* NAL.) DURING THE FREE LIVING PHASE OF ITS LIFE CYCLE.

By B. D. SMITH.

In 1957 an investigation was begun at Long Ashton into aspects of the behaviour of the Black Currant Gall Mite which might lead to the development of new control measures or improvements in those in present use. The life cycle of this mite can be conveniently divided into the free living phase and the bud-confined phase. The present account deals with the free living phase which commences with the emergence of mites from " big buds " in spring and ends when the last successful migrant has penetrated an axillary bud on new growth. There is no further migration until the following spring.

Factors affecting the emergence of mites.

A number of mites are ready to migrate as early as mid-February but cannot escape from even the largest of the then rapidly swelling buds ; they emerge as soon as the buds begin to open, provided that climatic conditions are suitable. Temperature is the most important factor affecting the rate of emergence and acts both directly on the mites, whose movements are accelerated by a rise in temperature, and also indirectly, in that the desiccation of buds is hastened by increasing temperatures. It has been shown that mites are very susceptible to desiccation and move away from places of low humidity. At the same temperatures they emerge much more rapidly from buds that are browning and drying out than from buds with greener tissues.

Fig. 1 illustrates the close correlation between temperature and the rate of emergence. Buds of similar size were exposed at various temperatures and the emerging mites were collected at hourly intervals by a suction apparatus. It will be seen that upwards of 800 mites per hour were released at a temperature of 80°F. ; Taylor (1) has estimated that under favourable migration conditions an average infested bud may set free 1,000 mites per hour.

Times of emergence.

Mites can be found on the outsides of infested buds in early March, when the healthy buds have burst and the larger infested buds have swollen and opened slightly. However, these mites cannot survive until the axillary buds are formed. When infested buds were experimentally removed after some of the early migrants had reached the stems it was found that the mites could survive only for a few days, even under the shelter afforded by normally developing leaf tissue. The main emergence period extends from the beginning of April until the end of June, with a peak usually in May. The proportion of mites which migrate at various times during this period varies each year with the climatic conditions ; whilst these have an immediate effect on emergence and migration they also affect the rate of development of the plant. As a result, considerable numbers of mites can be found migrating from the " grape " stage onwards.

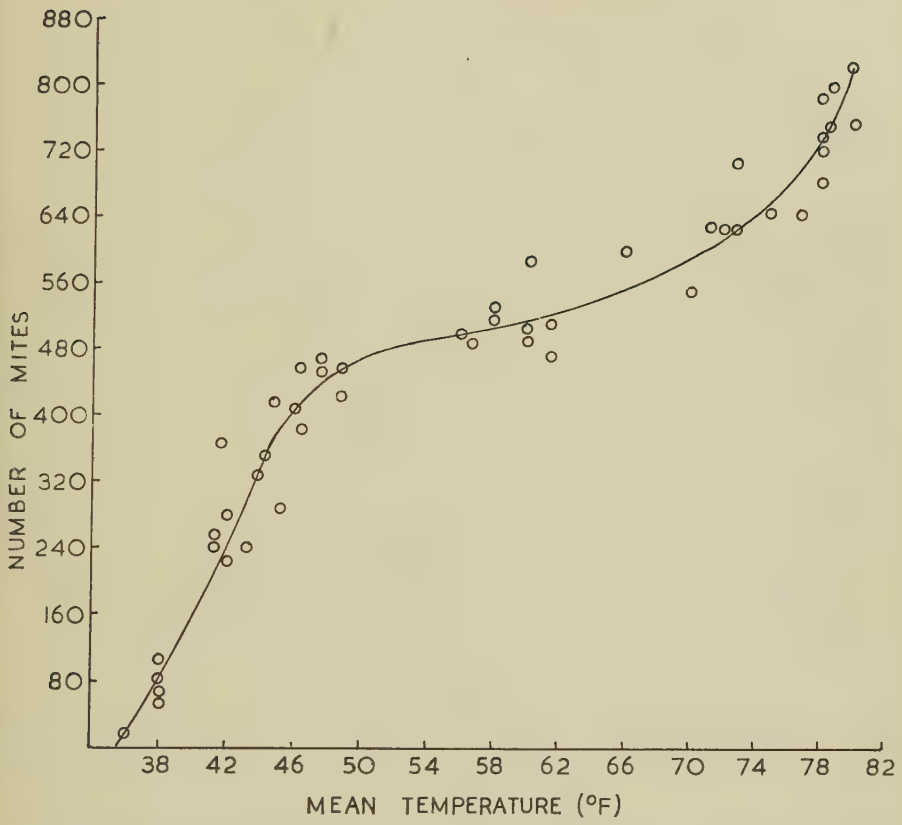

Fig. 1. Relation between mean temperature and number of mites emerging per hour from a single bud.

An experiment was made in 1959 in one Long Ashton plantation to determine the period during which mites could infest new buds. From March 25th onwards collections of infested buds of similar size were made at weekly intervals and equal numbers of these were attached by pins to new growth on groups of potted mite-free plants which were then isolated in cages made of fine nylon ; later in the season counts were made of mite-free and infested buds. The results (Fig. 2) showed that the highest percentage infestation occurred when buds were exposed between the 9th and 16th April, which in the variety Baldwin was about the 50% blossom stage. Collingwood and Brock (2) in a similar experiment found that in 1958 the highest infestation occurred in mid-May in the post blossom period, and concluded that this was the most critical period for spraying.

It will be seen from Fig. 2 that up to May 14th there is a direct correlation between the mean temperature and the infestation observed. Although mites and plants are influenced by climatic conditions, the mites show a more immediate response, and the period of greatest migration may coincide with somewhat different growth stages in different years. There are each year a number of mite eggs that hatch after the main emergence period, and the

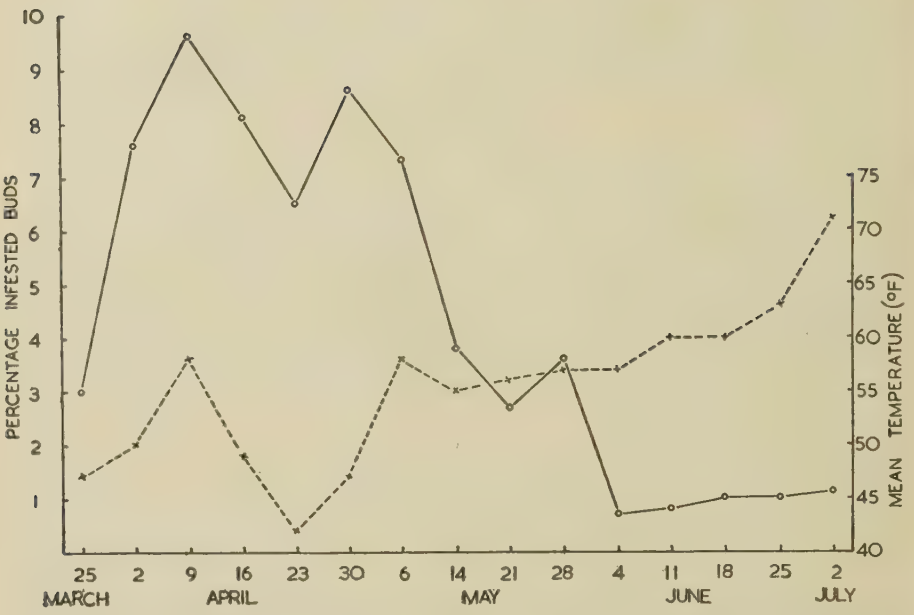

Fig. 2. Percentage infestation of buds exposed to mites for weekly periods (continuous line) and mean temperatures (broken line).

resulting mites can be found emerging and behaving normally in late June and early July. These individuals are not as effective in infesting new buds as those emerging in the main migration period, as their chances of surviving desiccation are greatly reduced because of the greater distances they have to crawl to reach suitable buds ; the growth of shoots has lengthened the distance between old infested buds and new buds, and the first-formed buds have by late June developed beyond the stage of easy penetration. Experiments have shown that these late-emerging mites will enter and reproduce normally if brought into the proximity of suitable buds.

Mites may also emerge after the main migratory period if they have been trapped between tissue within the buds ; this commonly occurs as smaller infested buds open, and is responsible for short delays. Longer delays often occur where blackcurrants are grown in sheltered damp situations ; here mites can be observed in July on the outsides of infested buds that are greenish and show no signs of desiccation. Differences can be found within a single bush in the proportion of the mite population that has emerged from buds on the outside and from those of similar size in the centre near the ground. On one bush in a damp situation at Long Ashton 87% of the mites had emerged by the 25th May, 1959, from six buds on the top, compared with only 42% from six similar buds at the base of the bush.

Both nymphs and adults migrate, and appear to behave in a similar manner. Emergence is continued at night if temperature conditions are suitable, but there is little or no movement from the outside of the buds until the following morning.

Behaviour of mites after emergence.

When mites emerge from an infested bud they move for a short period over its surface and then, if the temperature is over 50°F. and the surface dry, they stand erect. At higher temperatures the interval between emergence and standing erect decreases. The four main methods by which mites leave infested buds consist of crawling, leaping, invertebrate transportation and rainwashing.

Crawling. Mites crawl in all directions over the buds, but when they reach the stems they exhibit directional responses. Experiments showed that whilst they are crawling mites show no response to gravity but a positive response to light, and provided that the intensity is not too great, they will crawl towards higher light intensities. These responses ensure that mites generally move toward the outsides of bushes and so to the most advantageous sites for dispersal to other bushes. The rate of crawling varies with temperature, rising from 4·8 cm. per hour at 39·5°F. to 24 cm. per hour at 75·6°F.

Leaping. The ability of mites to leap by contracting their muscles on one side and springing has been referred to by many workers ; Taylor (1) believed that wind could carry them away when in the erect posture. Experiments were carried out to determine how important the leaping behaviour is in dispersal.

When infested buds were placed on pins at the centre of glass plates smeared with vaseline it was found that under relatively calm laboratory conditions mites were capable of leaping and travelling distances of up to two inches. Since the mites appeared to exercise considerable control over their leaping habit, apparatus was designed to find whether a correlation existed between wind speeds and leaping. The apparatus consisted of a large glass filter funnel inside which infested buds were supported just above the top of a piece of glass tubing. Compressed air at constant speeds was directed past the

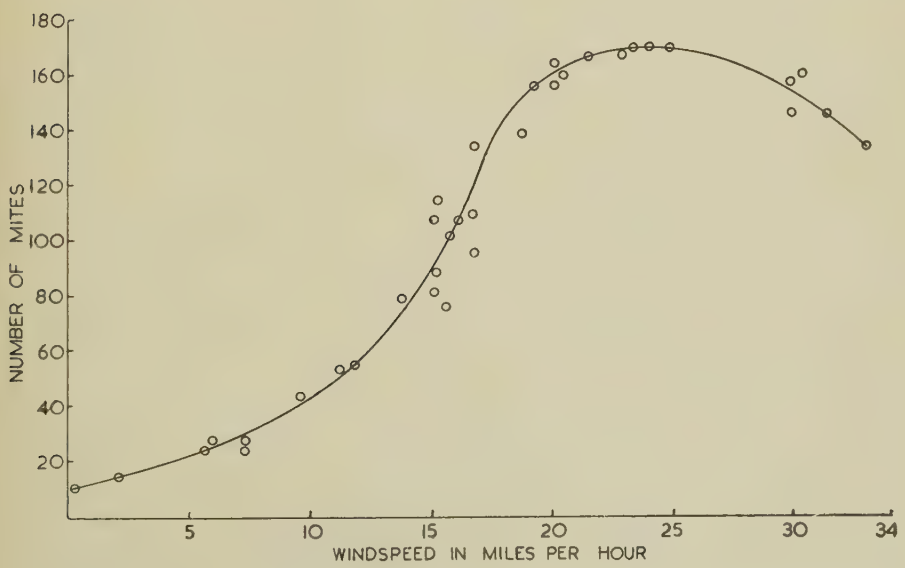

Fig. 3. Relation between windspeed and number of mites leaping per half hour from a single bud at 72°F.

infested buds down the glass tubing and between this and the outside of the funnel. Dead mites and those falling off were collected from the bottom of the glass tube, whilst those jumping off were collected by washing down the funnel walls. Using this apparatus at various temperatures it was shown that there was a close correlation between windspeed and rate of leaping.

The results obtained at 72°F. are given in Fig. 3. It will be seen that the number of mites that leaped per half hour increased with windspeeds from 0 to 24 m.p.h. Above 24 m.p.h. mites showed a decreasing tendency to become erect and appeared to be more firmly attached by their anal sucker-like structure.

By the time the main emergence of mites takes place there is a considerable amount of foliage on the bushes. To find how this affected windspeeds, measurements were made with a velocimeter above bush level, at bush level, between rows and within bushes. It was found that on typically breezy days in the blossom period windspeeds between rows were reduced to about a third of those above bush level ; at bush level there was about half this reduction : speeds within the bushes were much lower. For example, when the windspeed above bush level was 11 m.p.h. it was 8 m.p.h. at bush level, 4 m.p.h. between rows and 2 m.p.h. at the centre of the bush.

At the lower windspeeds found inside the bushes it is an advantage in dispersal for mites to be able to regulate their leaping as they do. Once they are airborne they are transported either by the wind itself or by various animals, usually invertebrates, although birds have been recorded as carriers. Wind prevents vertical falling and allows wide dispersal in the horizontal plane within the bush. This is also important in dispersal to adjacent bushes and to a lesser extent between rows of bushes. Few mites are found in the air above bush level, but the eddies set up at bush level in gusty conditions do bring some mites upwards, despite the fact that by the main migration time most of the old infested buds are masked by developing foliage.

Invertebrate transportation. The most important invertebrate carriers are insects, and mites can be found attached to almost all parts of insects' bodies ; frequently as many as 25 mites have been recorded on aphids that have walked over infested buds during the main migration period. Massee (3) states that in some years the currant aphid (*Hyperomyzus lactucae* L.) is one of the chief distributing agents of mites.

Several types of adhesive traps devised to estimate the relative importance of various carriers failed to give accurate assessments of mite and carrier relationships when large numbers of insects were being caught, because in struggling the insects dislodged their mites. On a revolving type of sticky trap situated beneath a wind vane many more mites were caught at windspeeds below 5 m.p.h., when the trap did not rotate, and this also applied to aphids amongst other carriers.

The greatest number of mites was carried by alate and apterous aphids ; the next greatest by small species of Diptera which were themselves more numerous in the traps than the aphids. Other carriers in order of importance were small Hymenoptera species, mainly Braconidae and Chalcidae ; other Homoptera, mainly Psyllidae ; Heteroptera, mainly Capsidae, and a few Coleoptera of which the Coccinellidae were the most frequent. Mites were occasionally found attached to thrips, small Lepidoptera and Neuroptera species, spiders and bees.

In laboratory experiments to determine how long mites could remain attached to carriers a rotary arm driven by an electric motor was used to carry aphids round at windspeeds between 2·5 and 20 m.p.h. ; the aphids were attached by the thorax to fuse wire on the end of the arm, and an infested bud was brought into contact with them. The number of mites which attached themselves to the aphids was noted, counts being made at intervals until none were left. It was found that whereas mites remained attached to various appendages of aphids for 5 to 10 minutes at 20 m.p.h. they frequently remained attached for over 6 hours at 3 m.p.h. Similar data were obtained when aphids were kept flying freely in a small area for many hours, using apparatus designed by Dr. J. S. Kennedy.

Mites readily released themselves from carriers when these came into contact with plant surfaces. Massee (3) has suggested that mites may wait for a passing insect on which to leap ; experiments indicated that whilst the rate of leaping cannot be increased by passing objects it can be increased by small vibrations of the bud surface such as would occur when insects alighted or crawled over it.

Rainwashing. Mites can readily be washed down stems, and after showers they can be observed distributed in decreasing numbers downwards, so that in a short time, without any apparently harmful effects, they can be transported to areas of new bud formation on the vigorous growth near the base of bushes. Greenhouse experiments confirmed field observations when buds with emerging mites were pinned to the tops of shoots and the distances were noted to which mites were carried down by artificial rain. After 0·05 inches of artificial rain in 35 minutes, for example, 0·5% of the mites emerging from an infested bud had been carried to the base of a shoot 3 feet long.

Entry into new buds.

When mites arrive near newly forming buds they are attracted to the leaf axils ; on entering these they begin to penetrate the new bud tissue by crawling inside the outer scale leaves and continuing in a circular direction until the centre of the bud is reached. They enter new buds as soon as these appear but, as the buds become larger, penetration between the scale leaves becomes increasingly difficult, especially after the flower initiation stage has commenced in the latter half of June. Experiments at Long Ashton in 1958 and 1959 showed that in the post-blossom period in the variety Baldwin the average time taken by mites to reach the centre of new buds was 32 hours from entering the leaf axils ; it varied between 27 and 44 hours.

Mites are readily desiccated, and it has been shown that when exposed on the plant they can survive for longer periods as the atmospheric humidity increases. They move towards areas of higher humidity, and laboratory experiments indicated that the movement from the stems into the leaf axils is due to the higher humidity in these sheltered situations.

Savzdarg (4) has estimated that only 1% of all migrating mites succeed in penetrating young buds during the migration period. The importance of short exposure to mortality factors such as desiccation is reflected in the distribution of mites over the plant after emergence. They are found in numbers only along the shortest routes between old infested buds and axillary buds : on the stems and in leaf axils ; only occasionally are they found on the exposed

leaves and blossom trusses. In analysing the distribution of infested buds on a bush, Lees (5) found that the earliest buds formed on a shoot, including the terminal bud, were most frequently infested, and he believed that buds immediately below the terminal bud and those at the extreme base of the shoot remained free from attack because they were formed after mite migration. Collingwood and Brock (2) found that almost all new buds had become visible by fruit set, and they could find no particular pattern of infestation.

As a result of their movement towards the shoot tips and their habit of burrowing deeply, once there, concentrations of mites are frequently found on infested shoots near the region of apical cell division. Experiments have indicated that provided the source is near the base of a shoot, and the infestation not so heavy that the apical region is seriously damaged, then the terminal bud has a greater chance of becoming infested than those immediately below it.

Summary.

In field and laboratory studies of the Black Currant Gall Mite (*Phytoptus ribis* Nal.), it has been shown that temperature controls the rate at which mites emerge and their subsequent rate of movement ; it determines the main migration period, which does not appear to be closely correlated with a particular growth stage of the plant.

Dissemination of the mites by crawling, leaping, invertebrate transportation and rainwashing is discussed in relation to their spread within a bush and to bushes at varying distances from the source of infestation.

The effects of desiccation on mite behaviour are considered and the method by which they enter newly formed buds is described.

Acknowledgments.

Thanks are due to Professor H. G. H. Kearns for his interest and advice in the investigation, to Mr. A. Baker for help in recording and to the Field Officers of Messrs. Beecham Foods Limited for supplying plant material.

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EFFECTS OF TEMPERATURE AND PHOTOPERIOD ON BLACK CURRANTS AND ON THE BEHAVIOUR OF THE GALL MITE (*PHYTOPTUS RIBIS* NAL.)

By B. D. SMITH.

In an investigation into the biology of the Black Currant Gall Mite (*Phytoptus ribis* Nal.) plants were required at growth stages earlier and later than those of bushes in the field.

Dr. D. Hoyle, of Reading University, had advised us that dormancy in black currants could be terminated by keeping them at 40°F. and then exposing them to a day length of 16 hours. In 1958 groups of 24 two-year-old potted black currants of the variety Baldwin were therefore kept for varying periods at 40°F. in a cold store and then at 65°F. in a greenhouse where they could receive long photoperiods. The percentage of buds that opened was determined by the period at 40°F. After 9 days cold treatment 12–16% of the buds broke ; after 27 days, 34% ; after 64 days, 67% ; and after 92 days the maximum of 81% buds broke. The natural percentage break in the field for the variety Baldwin at Long Ashton was between 79 and 92%. Long periods in an unheated greenhouse, in which the temperature did not fall below 43°F., failed to compensate for periods at 40°F. in increasing the percentage bud break.

The time taken for buds to break on the treated plants was inversely proportional to the period spent at 40°F. : 22 days were taken after 9 days cold treatment but only 3 days after 71 days treatment. When bud break was only partial, the uppermost buds usually broke first ; they invariably developed much more rapidly than those that broke a few days later. Blossom trusses appeared on even the most inadequately cold-treated plants, but fruit-set was good only on plants receiving more than 60 days cold treatment.

Eggs of mites were only occasionally observed in infested buds during December, but their numbers increased steadily from January onwards. Savzdarg (1) states that the correlation between the winter resting stage of the plant and that of the pest, and also the summer latent period in the mites' reproduction, characterize the hereditarily established close adaptation of the mite to seasonal changes in the physiological and morphological status of the bud.

As Hoyle (2) has shown, black currants can be grown continuously with a photoperiod of more than 17 hours. Plants kept growing from September to March were used to determine whether mites have a simple resting stage or a true diapause. Egg laying was not continued ; when the centres of infested buds became brown most mites died within 4 weeks, but when bud centres remained green most mites remained alive for 8 weeks. When plants that had been apparently dormant for several weeks were given long photoperiods and higher temperatures, occasional buds broke, but mites did not commence egg laying, although they survived for 2 to 3 months.

On similar plants given 14 days cold treatment after becoming dormant, a larger percentage of buds broke and a few eggs were subsequently observed. As the period of cold treatment increased so did the proportion of eggs to mites during the 12 days following the end of the cold treatment. Mites therefore appear to have a true diapause which begins after the plant has become

dormant and which, like the plant's dormancy, can be terminated by low temperatures. The time at 40°F. necessary to obtain a ratio of eggs to mites similar to that occurring naturally was 4 to 5 weeks, whereas the plant required more than 12 weeks before the proportion of buds breaking was similar to that in the field. In plants in which a short dormancy had been terminated by cold treatment mites did not lay eggs ; nor did they survive in the buds of these plants, which swelled, but failed to break because they had received higher temperatures and only a short photoperiod.

Lees (3) states that diapause should primarily be regarded as a timing mechanism whose function is to ensure that the active stages are present when food supplies are plentiful and when conditions of temperature or moisture are suitable for their development. The extent to which diapause in mites is dependent on the physiology of the plant as a whole was investigated by removing shoots and buds from plants after they had received sufficient cold treatment to induce a normal amount of bud break. In the infested buds on the detached shoots, the proportion of eggs to mites was approximately half that in those left on the plant, on which the proportion of buds breaking was no higher than on the detached shoots. In separate buds kept in damp sand only occasional eggs were subsequently observed. Thus, although a shorter cold treatment was required to break the mites' diapause than to break the plant's dormancy, the plant was still controlling development after diapause had been terminated.

It has not yet been possible to culture mites on artificial media or on tissues detached from the plant. The quantities of material observed inside their bodies suggest that mites feed more readily at the centres of buds than on the more developed outer leaves, and more in vegetative buds than in potential flower buds, where they prevent flowers from developing. That reproduction in newly infested buds is delayed until late June may be due to unfavourable nutritional conditions during the period of flower bud initiation ; Savzdarg (1) suggests that this delay may also be correlated with high osmotic pressures in the cell fluids. How readily the plant can influence mite behaviour was observed when plants were removed from soil at the post-blossom stage and placed in demineralized water. Although the plants appeared to continue to develop normally, the interference with their physiology was sufficient to delay the onset of mite reproduction for several weeks.

Summary.

The behaviour of the Black Currant Gall Mite has been studied in black currants in which dormancy was either broken, or prevented from occurring, by changes in temperature and day-length.

The overwintering phase of the parasitic mite's life cycle appears to include a true diapause during the host plant's dormancy ; the host plant regulates the timing of this diapause.

The time interval before egg laying commences in newly invaded axillary buds also appears to be dependent on the physiology of the plant.

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PRESENT TRENDS IN APPLE UTILIZATION.

By A. POLLARD.

A good deal of attention has been given in the last few years to the organization of top-fruit growing in this country, and especially to problems of grading and marketing apple supplies. The adequate utilization of the lower grades for processing has been under discussion for many years, but the problem has now been given added urgency, since apple production is increasing and a wider adoption of grading schemes will throw more fruit into the lower categories. These trends are not confined to the United Kingdom, for increased fruit plantings, coupled with advances in horticultural methods, have led to an increased fruit production in Europe as a whole. Many orchards have not yet come into full cropping, hence the pressure of apples is likely to increase still further in the immediate future. In this country between a quarter and a third of the dessert fruit plantings are less than seven years old, and between 70 and 80 per cent. are under thirty years old.

As matters stand at present there is over-production in several countries in many years, and a proportion of this surplus is exported in one form or another. In many seasons West Germany has acted as a safety valve, but fruit production there is now increasing and the need to import apples may decrease in the future, though the German processing industries are admittedly confident of future expansion. The production of table fruit is also increasing in other countries that are members of the Common Market, notably in France and the Netherlands as well as in Italy, where the increase has been steepest. Exports to neighbouring countries are likely to prove more difficult as production increases within the group as a whole.

The growers in this country can therefore be expected to remain increasingly vulnerable to competition, not only by table fruit competing for the retail market, but by processed fruit, in one form or another, that discourages the uptake of the lower grades produced at home. As shown by the N.F.U. survey, it should be possible to stimulate the retail trade in apples, for the per capita consumption here of 30 lb. is much lower than that in some countries, notably Switzerland at 87 lb. and Sweden at 75 lb. (1). A better market for table fruit would assist the sales of the lower grades at a price acceptable to both grower and processor.

It was agreed at the Wye Conference on Orchard Fruit Production in 1958 that the necessary re-organization of the industry involved not only improvements in marketing, with adequate publicity, but an efficient grading system that would keep the lower grades from the retail market. The problems were discussed at greater length at the Commonwealth Fruit Producers' Conference held in June 1959 (2), at the Malvern Fruit Conference in November of that year, and in the press. It is now accepted that additional outlets must be found for sound fruit in the lower grades, or that present outlets must be expanded.

The nature of the problem.

The problem is not new : it exercised the minds of growers in the years before the last war. At that time it was hoped that an apple juice industry would help to resolve the situation, but war-time restrictions and other factors

limited progress. In some ways the position is now more promising, a main factor being that the surplus is largely of dessert varieties rather than of sharp cookers ill-suited to juice production : the fruit available is more balanced in composition. In the years round about 1950, dessert fruit represented about 30% of total production : it is now over 40% and is expected to increase to over 50% in the next five years.

The total tonnage of table apples produced in this country in the past five years has exceeded 500,000 tons in many seasons and, according to figures presented at Wye and Malvern, it is expected to increase in the near future. Although there will be some fall in culinary fruit, the dessert fruit supplies are expected to increase by some 35,000 tons.

The main outlets for processing apples are as canned fruit, pulps and similar products, and as cider and apple-based drinks. The uptake by the cider industry varies according to the tonnage of true cider apples available. This latter category is normally absorbed fairly completely by the industry and does not enter into the present discussion directly : it may, however, affect indirectly the uptake of non-cider varieties. The amounts of fruit used for manufacture other than for cider, and excluding wastage, have been estimated as between 25,000 and 35,000 tons annually from 1950-56 (3). Some later estimates have been below this amount and others above it ; until this discrepancy is resolved it can only be assumed that the total uptake, including the cull fruit used for cider, may be of the order of 50,000 tons. This would amount to some 10% of the total crop and, whatever the precise figure may be, it is evidently insufficient. The proportion of fruit falling into domestic and cull grades over the country as a whole is more likely to be 20% in the future ; in other words, the uptake may need to be doubled.

Trends in other countries.

This problem should not prove insuperable when it is considered that in West Germany alone some 300,000 tons of apples were in 1958 converted into juice by the factories and small producers (4, 5) and that in Switzerland the uptake for processing in that year was raised from the usual 120,000-170,000 tons to nearly half a million tons (6). Alcohol production was admittedly responsible for some of the latter increase but the production of concentrated juice was also augmented. The extensive fruit production in Switzerland has long been a problem in its economy, but the processing industries now established by private and public initiative have resolved it in normal years, provided some surplus juice or concentrate can be exported.

France is now being presented with the situation that faced Switzerland in the inter-war period. The excessive production of cider apples has long been an embarrassment only partially mitigated by State purchases of alcohol. Anti-alcohol propaganda and Decree No. 53-703 of the 9th August 1953 are now changing the situation (7). The object of the decree is to reduce alcohol production gradually, to reserve this as an outlet for low grade ciders that should not appear on the market, and to use it as an emergency measure for dealing with excessive crops in certain years. The production of non-alcoholic products, juice and concentrate, is to be encouraged by financial assistance, and the distilleries are to be reduced in number by closure, or their output is to be reduced by quota. Loans will be available for re-equipment, to assist

in maintaining and holding stocks of juice or concentrate, with financial aid to compensate losses incurred by exporters.

It is hoped that these governmental measures will encourage and increase the production of unfermented apple juice as a beverage in France, a development paralleling those in unfermented grape juice. This may not conflict with the interests of growers here : it could provide a useful example. The increased production of juice concentrate that will be put upon the European market must, however, increase competition in apples and apple products among the different countries.

The situation of the growers in this country has much in common with the position some years ago in Canada, although the factors concerned are not the same. The growers here are faced with outside competition whereas in Canada fruit surpluses arose by the restriction of export markets. The history of the Canadian industry and the developments in processing were outlined by Mr. R. P. Walrod at the Commonwealth Fruit Producers' Conference : the progress made in British Columbia is particularly relevant. Many of the early ventures designed to utilize surplus Canadian apples broke down through failure to apply basic scientific and economic principles : later, canning and dehydration plants were developed and a portion of the surplus was utilized. The major advance came when the growers took over the existing by-product plants and created a new company to be responsible for salvaging the cull fruit and, eventually, the lower grade commercial fruit that was increasingly to be kept from the retail market. This body, now Sun Rype Products Limited, has since expanded and widened its range of manufactured products. It now absorbs one-third of the total crop in British Columbia, making as main items apple juice, apple sauce and pie fillings : the canning field is otherwise left in the hands of private companies. Other products made include vinegar and concentrate, dehydrated and frozen apples ; more recently a light cider has been put on the market, but its development has been hindered by existing legislation.

The development of apple juice in Western Canada, since it was first marketed in 1940, is of particular interest. After initial difficulties it received support from the Federal Government as a means for supplying ascorbic acid to the public as a war-time measure. This assisted its technical and commercial development so that later, when it met increasing competition from citrus and other juices, it was able to survive and in fact to take advantage of the increased demand for juices of all types. The concentration of the industry in the hands of one central agency was invaluable in the maintenance of quality and the organization of publicity. Efficient publicity directed at the consumer and at the medical and dental professions has now brought the industry to the stage at which a short crop necessitates restriction of the allocations to consumers unless juice can be made available from other areas and processed under licence. The per capita consumption of 3·8 lb. now exceeds that in the United States and is exceeded only by that in Germany (5·8 lb.) and in Switzerland (22.5 lb.).

In the United States, processing now absorbs over one-third of the apple crop of about two million tons. The main products made are sauce and baby foods, frozen and canned slices, dried apples, cider vinegar and apple juice. The various canned and frozen products represent rather more than half of the fruit going into the factories, juices about a quarter (2).

The production of apple juice in the United States is of long standing, but only in recent years has the amount increased to any marked extent. Two types are put on the market, a factory-produced apple juice and an unprocessed —mainly cloudy—juice made by the growers in the harvest season and sold as apple " cider ". In recent years there has been an increase in the production of both these types and each accounts for about 4·5% of the total apple crop, giving a total volume of about 33 million gallons (8).

Current Developments.

If a larger proportion of apples is to be used by the processors in this country, the type of product made must absorb an appreciable tonnage. Luxury products with a restricted sale will be of little use to the fruit-grower. Products that make use merely of individual fruit components—the pectin, the acid or the sugar—will similarly offer limited prospects, for their production will be uneconomic unless the rest of the fruit can be utilized ; moreover, they present the manufacturer with the problem of waste disposal. The ideal production channels make use of the whole fruit or a great part of it, as in canning, or, alternatively, the juice is utilized and the pressed residue is used as fodder or as a source of pectin or other by-products. The production of canned goods can be increased if the industry can compete with those now established or developing in the other European countries. At the same time the sale of fresh fruit must be maintained, or better, further stimulated ; the mere diversion of fruit from the retail market to the canner will not help the grower. Semi-processed apples for the catering trades seem less vulnerable to competition, and this type of product is now undergoing development in this country (9).

The obvious outlet for surplus fruit is in the production of apple juice, for this makes use of the greatest proportion of the apple and leaves a manageable residue. The volume of juice given by 50,000 tons of apples would be about 8 million gallons, rather more than one pint per head of the population. This is comparable with the consumption of apple juice in the United States, where the total consumption of other juices, mainly citrus, is nearly twenty times greater than that of apple juice.

Although the example of countries producing apple juice in Europe has long been held up to growers and manufacturers in the United Kingdom, their response until recently has been very limited. This is not surprising in view of the past history of the product. Although production began here in the 1930s, the outbreak of war, technical difficulties, high cost of manufacture, and competition from other beverages, halted the development of the young industry. Other factors such as variability of product, lack of publicity, and the indifference of the public, also made their contribution. As shown by Dalrymple (8), the position in the United States has been similar, but there the consumption of apple juice was originally high ; its popularity then declined and only in recent years has it regained favour : apple juice is now once more making headway.

The lead in recent developments has mainly come from Canada where the Growers' Co-operative in British Columbia, working with the Summerland Research Station, has put a new series of apple juice products on the market (2). Natural cloudy juices and blends with other fruits are not new and have been

marketed in the past in both the United States and Europe, but it is only recently that their full potentialities are being developed. The classical clear apple juice, as produced here and in Europe, called for expensive plant and equipment involving pressure tanks for storage with refrigeration, and although later modified techniques have cheapened the process, the initial outlay on equipment has hindered development in many countries. Cloudy juices are simpler to produce, since clarification processes are eliminated, and minor changes in opacity occurring later in the container are unimportant : by contrast, a haze or deposit in a clear juice may render it unsaleable. Cloudy juice can be processed directly from the press to the container ; the need for bulk storage does not arise if the blend of fruit can be kept sufficiently constant through the season.

In the past, cloudy juices have tended to be of lower quality than clear juices and to be variable in colour, flavour and appearance : by preventing oxidation the Canadian technique overcomes these problems to a great extent. The fruit is chilled, pressed rapidly and the juice treated with ascorbic acid ; this delays oxidative changes sufficiently for the juice to be strained and flash-pasteurised directly into the container. The juice retains its natural opalescence and fresh apple flavour. The method is now patented in North America and is being operated in the United States under licence.

A main advantage of this product is that the juice can be blended with juices or purées derived from other fruits, clear or cloudy, to give a range of flavours. Blends with citrus fruits, stone fruits and berries are now in production ; the apple juice forms a base supporting the utilization of other fruits that may themselves be surplus to the needs of the fresh fruit market.

These developments have not gone unheeded in Europe, where there has been some recession in the demand for clear juices because of competition from other soft drinks. A move towards the opalescent type of juice is now being made in Switzerland, where it is being realized that the industry must meet the demands of the consumer. Changes in consumer tastes are now also affecting the cider industry in that country, where a preference is becoming apparent for the English type of product higher in tannin and sugar content (10).

The situation now seems more favourable for apple juice in this country. The public has become accustomed to fruit juices, especially cloudy or pulpy products ; it is more travelled and has seen them abroad, and distribution chains are more efficiently established. The growers themselves now appreciate that an apple juice industry could help to resolve the present surplus fruit problem.

In the 1958 season experimental batches of apple juice and blended juices of the opalescent type were prepared at Long Ashton and were demonstrated on various occasions to growers and others interested in juice products. As a result, larger-scale tests were undertaken in collaboration with the Metal Box Company, and sample batches were distributed to growers' organizations and food manufacturers. Tests on a semi-manufacturing scale have since been undertaken and full-scale production of juices is now envisaged (11).

The tests so far made with English apples have shown that attractive opalescent juices can be made from blends of culinary and dessert varieties. A full range of varieties has not been used, attention being first directed to those available in greatest quantity. The varieties surplus to market requirements will vary according to season, but if the acid/sugar balance found most

suitable can be maintained, the problem of blending should not prove insuperable. If juice production is undertaken by a growers' organization it can be flexible, for varieties not required by the market can be directed to juice production, and those unsuitable for use as plain apple juice can be used in blends with other juices.

For example, an orange-apple juice incorporating orange juice or concentrate, or comminuted orange, requires a higher concentration of acid and sugar than apple juice alone. The precise nature of the apple varieties is less important and a higher proportion of culinary varieties can be used.

The juices so far made in some quantity have included apple juice alone and blends with orange, pineapple and apricot; the proportions of the components can be modified according to the predominance of apple or other flavour required. The results of detailed consumer preference tests are not yet available but the general reception has been very favourable. Some of the trials so far made are described in a later article (12).

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THE PRODUCTION OF OPALESCENT JUICES FROM ENGLISH APPLES: PROGRESS REPORT.

By MARGARET E. KIESER, A. POLLARD and D. J. SISSONS.

The type of apple juice produced in Europe is mainly the clear juice obtained after depectinization and filtration : some juice is sold directly from the press for immediate consumption and, in the United States, this unprocessed juice or " cider " is still an important part of production (1). Cloudy juices of this type are highly unstable and rapidly undergo microbiological and oxidative deterioration ; they have, however, the advantage of requiring the minimum of equipment for their production. As recorded by Joslyn and Tressler (2) there have been numerous attempts in the past to prepare stable cloudy " natural " juices that retain the pale colour and fresh flavour of apple juice as it leaves the press. In 1947 and 1948 Pederson and co-workers demonstrated that oxidation could be retarded by spraying the fruit or milled pulp with an ascorbic acid solution before milling (3,4,5) : this gave time for the juice to be flash-pasteurised into the container before the onset of enzymatic browning and changes in flavour.

As described in the previous article (1), commercial development of this type of juice began in British Columbia, but it was limited by technical difficulties : losses of ascorbic acid were excessive and large additions were necessary if the juice was to contain an appreciable level of the vitamin when it reached the consumer. Methods involving juice extraction under nitrogen were not entirely satisfactory. Eventually it was found that the simple addition of ascorbic acid to the juice pressed from chilled fruit was highly effective in retarding oxidation and that the addition of 50 mg. per 100 ml. of juice ($2\frac{1}{4}$ g. per gallon) left at least 35 mg. per 100 ml. in the juice after one year's storage (6).

Blends of opalescent juice with other fruits are now also in production in Canada : these differ from clear juice blends described by earlier workers (2) in carrying varying amounts of fruit pulp in suspension. Juices or purées of more highly flavoured fruits can be blended with apple juice, which is usually cheaper than the other juices, to give products richer in flavour and body than comparable products made merely by dilution with water.

These general methods have been followed in the tests carried out at Long Ashton but, in addition, other exploratory tests have been made to study in more detail the behaviour of English apple varieties and to determine the most suitable methods of juice preparation.

Experimental.

In large scale trials the Canadian method for opalescent juice was followed as far as possible. A blend of culinary and dessert apple varieties was chosen, in the proportion of one part culinary varieties to two parts dessert for apple juice alone. Equal parts of the two types were taken for blended juices of higher acidity in which it was intended to increase the specific gravity by the addition of sugar. The optimum balance of acid and sugar will depend upon consumer preference ; present indications are that for apple juice the ratio of degrees specific gravity to percentage acidity (as malic) should be about 80,

e.g., S.G. 1·048 (48 degrees) for a juice with an acidity of 0·6% or S.G. 1·056 for an acidity of 0·7%. For blended juices the ratio may lie over the range 70 to 90 according to the type of product.

Apple Juice.

The varieties used were mainly Bramley's Seedling, Cox's Orange Pippin and Laxton's Superb. Other varieties found satisfactory in blends with these varieties were Worcester Pearmain, Tydeman's Late Orange, Ellison's Orange and Allington Pippin : few others have yet been tested. The fruit was chilled to 0–2°C. (32–36°F.), milled and pressed without delay, and ascorbic acid was added to the pressed juice at the rate of 2 g. per gallon (44 mg. per 100 ml.). The juice was strained through muslin and flash-pasteurised into plain tinplate cans or into bottles ; the temperature of filling was normally 93–95°C. (199–203°F.). Cans were held for 5 minutes before cooling ; crown corked bottles were previously heated in hot water before filling, crowned and held for 10 minutes before cooling.

Blended Juices.

Apple juice blends were prepared by combining the freshly pressed juice, after addition of ascorbic acid, with orange and pineapple juices or concentrates, or with apricot purée. Additions of sugar syrup, citric acid and water were made according to the type of product. The proportion of apple juice varied from 50% to over 80% according to the intensity of flavour of the other components : in orange blends the use of comminuted preparations incorporating peel fractions gave products with a strong orange flavour at the higher apple juice levels.

Ascorbic acid retention.

The retention of ascorbic acid, as determined by direct titration with 2,6-dichlorophenolindophenol, is shown for some stored canned and bottled

TABLE I.

RETENTION OF ASCORBIC ACID IN CANNED AND BOTTLED JUICES.
(mg. per 100 ml. juice).

Code No.	Juice	Container	Storage period (months) 0	3	6	9	12
318	Apple	Can	48·5	—	—	41·5	40·0
		Bottle	48·5	—	—	37·0	37·0
922	Apple	Bottle	36·0	33·0	35·0	29·0	
819	Apple-orange	Can	45·0		42·0	41·0	42·0
		Bottle	45·0		38·5	36·0	37·0
933	Apple-orange	Can	35·0	35·0	32·0	32·0	
		Bottle	35·0	34·5	31·0	31·0	
A1S	Apple	Can	49·0	49·0			
A2S	Apple	Can	37	35·5			
O2S	Apple-orange	Can	50	47·5			

products in Table I ; all samples had been stored in a cool cellar in dim light. The retention is higher in can than in bottle and, from the limited data yet available, appears comparable with that found by the Canadian workers.

The losses of ascorbic acid to be expected during the period between juice pressing and flash-pasteurising are shown in Table II. The rate of loss is greatest immediately after pressing, for after 20 minutes any ascorbic acid present in the fruit itself has disappeared together with some of that added.

TABLE II.

EFFECT OF PROCESSING PERIOD UPON ASCORBIC ACID RETENTION IN APPLE JUICE.

Blend : Bramley's Seedling, Cox's Orange Pippin, Allington Pippin, Ellison's Orange.

Time interval between pressing and flash-pasteurising	Ascorbic acid in juice as canned (mg. per 100 ml.)
—	(43·3 mg. added)
20 min. at 4°C.	39·3
1 hr. „ „	35·7
3¼ hr. „ „	32·1
5 hr. „ „	30·6
3 days „ 0°C.	19·4

The effect of fruit temperature upon ascorbic acid retention is shown in Table III. In this test, fruit held overnight at 0°C. gave, after milling, a pulp with a temperature of 4·5°C. : the retention of ascorbic acid during processing was only slightly greater than that in fruit held at cellar temperature (8°C.). In juice from fruit held at a higher temperature there was a greater loss of ascorbic acid ; the higher pectin content of this last juice may be the result of increased metabolism in the fruit during two days' storage at the higher temperature, but the acidity and specific gravity were unaffected.

TABLE III.

EFFECT OF FRUIT TEMPERATURE ON ASCORBIC ACID RETENTION AND ON JUICE COMPOSITION.

Blend : varieties as in Table II.

Temperature of fruit (°C.)	0	8·0	14·0
Temperature of milled pulp (°C.)	4·5	8·0	14·0
Temperature of pressed juice (°C.)	6·0	9·0	12·0
Ascorbic acid after canning (mg. per 100 ml.)	43	42	35
Pectin content of juice (as per cent. Ca pectate)	0·118	0·123	0·142

Fruit maturity and juice composition.

Earlier work on the preparation of clarified apple juice had shown that beyond a certain stage of maturity, dependent upon the variety of fruit, juices were lower in specific gravity and acidity, and inferior in flavour (7,8). Preliminary work on opalescent juices showed that immature fruit gave almost clear but thin juices with starch in suspension, whereas gas-stored fruit pressed late in the season gave juices that were palatable but increasingly lacked flavour as the season progressed.

In the 1959–60 season batches of culinary and dessert apples were held from the end of October in a cool store (2–5°C.) for varying lengths of time before pressing. As shown in Table IV, after one month's storage the juice showed a fall in acidity and an increase in pectin, but little change in specific gravity. After three months both acidity and specific gravity had fallen. The juice from the first pressing (M1) was only slightly cloudy ; the juices from the later pressings, with higher pectin contents, were strongly opalescent. The juice M2 was judged to have the best flavour, M1 was rather acid, whereas M3 had lost some character but was free from any abnormal flavour.

TABLE IV.

EFFECT OF FRUIT MATURITY ON JUICE COMPOSITION.

Blend : Bramley's Seedling, Cox's Orange Pippin, Laxton's Superb, Ellison's Orange.

Code No.	Date of milling	Specific gravity	Acidity (as per cent. malic)	Pectin content (as per cent. Ca pectate)
M 1	20.10.59	1·049	0·75	0·034
M 2	26.11.59	1·048	0·69	0·097
M 3	26.1.60	1·043	0·58	0·100

Pasteurization temperature.

Early attempts to flash-pasteurize and cold-fill juice into sterile crown-corked bottles were abandoned because of mould infections which sometimes appeared during storage and led to flavour changes and clearing of the juice by depectinizing enzymes produced by the organisms. These flash-heated and cooled juices were no better in flavour than the hot-filled juices prepared later.

To determine the heat treatment necessary for ensuring effective sterility, a batch of juice was prepared and filled into cans at three different temperatures ; at each temperature the holding time before cooling was varied. Sterility tests carried out by a modification of the Presumptive Coli Test, using suitable media, are summarized in Table V. The numbers of organisms present in the cans tested were extremely small and, at the higher temperatures, were probably the result of chance contamination during filling, since this operation was not mechanized. The greater incidence of organisms in juice filled at 88°C. and cooled immediately suggests, however, that this heat treatment may be insufficient. No organisms could be detected in juice samples taken immediately after canning and not incubated.

TABLE V.

STERILITY OF CANNED OPALESCENT APPLE JUICE AFTER HEAT TREATMENT.

Heat treatment Filling temperature °C	Holding time min.	*Counts per 100 ml. in cans sampled after storage at 25°C* Weeks 0	1	4	5	6	7
95	0	0	0	0	0	0	0
95	3	0	0	1 M	1 M	0	1 M 1 Y
95	5	0	0	0	0	1 M	0
92	0	0	0	0	0	1 Y	1 M
92	3	0	0	0	0	0	0
92	5	0	0	1 Y	0	0	1 M
88	0	0	0	0	3 M 1 Y	1 M	1 Y
88	3	0	0	0	0	0	1 M
88	5	0	0	0	0	0	1 M 1 Y

Y = Yeast ; M = Mould.

The differences in flavour due to heat treatment were small, and some tasters were unable to differentiate between juices canned at 88°C. and those canned at 95°C. Others detected a difference and preferred those canned at the lowest temperature and held for the shortest period before cooling.

The present tests indicate that the minimum heat treatment required is 88°C. with holding for 3 minutes before cooling.

Conclusions.

The tests so far undertaken suggest that the apple varieties used, if they are in sound condition, are suitable for conversion into opalescent apple juice or blended products, and that their behaviour is not dissimilar from that of the Canadian varieties used for this purpose. Ascorbic acid effectively retards oxidation during processing, and the stability of ascorbic acid during processing and storage in the can is of the same order as that found in British Columbia. The results confirm that the fruit must be chilled as near to 32°F. as possible and preferably processed within half an hour. Slight departures from this procedure, if they are cumulative, can lead to larger losses of ascorbic acid ; if a declared content of the vitamin is required in the juice after storage, this may entail the addition of a significantly larger quantity initially.

It is evident that fruit pressed before full maturity is unsuitable for this type of product, for the juice is thin and lacking in the pectin needed to keep the colloids of the juice in suspension. Apples can be held in store for a considerable period before the juice takes on any abnormal flavour, and so long as the fruit is of good eating quality it should be suitable for juice production.

The optimum blend of varieties and the most desirable acid/sugar balance are yet to be determined, but the types of fruit commercially available should provide adequate flexibility for the producer.

The heat treatments given in the present trials have been intentionally more drastic than those used commercially in British Columbia, but they do not appear to have affected juice quality unduly. The severer treatments were adopted because of the development of moulds in earlier bottled samples. It is also for this reason that the tests have been so far mainly restricted to canning, where the problem of container sterilization is simpler. The incidence of certain heat-resistant moulds capable of growth in the container appears greater in Europe than in North America (9).

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THE PRESERVING QUALITIES OF SOME VARIETIES OF HIGHBUSH BLUEBERRIES.

By ALICE CRANG and MARGARET LEACH.

Highbush blueberries are an important soft fruit crop in the U.S.A. Trials of some of the varieties that have proved most successful in the U.S.A. have been made by the N.A.A.S. at Sugar Hill near Bere Regis (1); during the last three years a number of these blueberries have been tested for their preserving qualities.

Experimental.

The blueberries were picked when ripe, transported by car in 1 lb. punnets in containers cooled with solid carbon dioxide, and held overnight. Each variety was tested for fresh fruit quality and preserved by bottling and/or freezing, according to the amount of material available; some varieties were also made into pies.

The average weight per berry was determined for each variety in fresh fruit from which leaves and damaged berries had been removed. Samples were then placed in small polythene bags, which were sealed after removing excess air, and frozen at −20°C. Determinations of pH value and of the content of ascorbic acid and soluble solids were made after freezing for 5 to 5½ months.

Ascorbic acid. The frozen fruit was weighed after thawing to room temperature in tared beakers containing 0·25% oxalic acid solution. The fruit and oxalic acid were then macerated for ½ min. in an M.S.E. homogeniser, and made up to 200 ml. with 0·25% oxalic acid. Using a spot galvanometer (2), aliquots of the strained homogenate were titrated against 2,6-dichlorophenol-indophenol, previously standardized against ascorbic acid.

As the quantities of ascorbic acid found were so small, a standard amount of ascorbic acid was added to each solution to ensure satisfactory titration curves. All titrations were carried out on the same day that the blueberries were thawed; all solutions were kept in the dark when not in use.

pH determinations. These were made on the thawed macerated fruit using a Pye electric pH meter; a mean of at least 3 readings was taken.

Soluble solids. A refractometer with a sugar scale was used for soluble solids determinations on the juice from the thawed berries, after straining through dry muslin. A mean of 3 readings was taken.

Quality determinations. 12 to 15 members of staff, forming a regular tasting panel, marked the fresh and preserved fruit for colour, texture and flavour. The method of scoring was that adopted in 1958 (3), with a maximum of 5 marks; 3 marks represents a good average mark in each category.

The fruit was bottled in all-glass jars, using 10 oz. of berries to 5 fl. oz. of 30% sugar syrup, and processed by the quick water-bath method (4). In 1957 and 1958 the frozen fruit also was preserved with sugar in these proportions, but in 1959 the berries were frozen without syrup.

Results.

The analytical results for 17 varieties tested in 1959 are given in Table I, together with the mean berry weight of the varieties examined in 1957 and 1958.

TABLE I.

BLUEBERRIES : WHOLE FRUIT FROZEN AT —20°C. FOR 5 TO 5½ MONTHS : 1959.

Variety	Average wt. of berries (g.)	pH value	Soluble solids (%)	Ascorbic acid (mg./100g.)
Berkeley	1·3	3·7	13	1·5
Bluecrop	1·2	3·3	14	<1·0
*øBurlington	0·8	3·5	13	<1·0
Colville	1·7	3·4	14	1·8
*øConcord	1·0	3·9	17	<1·0
Dixie	1·6	3·2	14	<1·0
GN 87	—	3·5	13	<1·0
Gold Traube I	—	3·4	14	<1·0
Gold Traube II	0·9	2·9	11	<1·0
Herbert	1·1	3·3	16	<1·0
*øJersey	1·3	3·3	16	2·0
*øJohnston	0·9	3·8	13	1·8
*øPemberton	1·4	3·5	13	2·7
øRancocas	—	3·7	14	1·0
*øRubel (1st pick)	0·9	3·5	13	<1·0
*øRubel (2nd pick) ..	0·6			
*øStanley	1·2	4·0	19	<1·0
Mean	**1·2**		**14**	**<1·0**
Mean 1958	**1·5** (for all varieties marked *)			
Mean 1957	**1·1** (for all varieties marked ø).			

The pH values and soluble solids contents are relatively high compared with those of most British soft fruits ; these are in accordance with values determined in the U.S.A. The ascorbic acid contents are, however, considerably lower than those reported in the U.S.A., where 8 varieties tested contained from 10·5 to 12·9 mg. ascorbic acid/100 g. when fresh, and about half these amounts after 9 months' storage as frozen fruit (5).

The relative assessments of quality in fruit bottled or frozen in 1957, 1958 and 1959 are given in Table II, while in Table III the quality of fresh fruit from the 1958 crop is compared with that of similar fruit made into pies after freezing and storing for 5 months.

TABLE II.

QUALITY OF BOTTLED AND FROZEN BLUEBERRIES.
(Maximum 5)

Variety	Year	Bottled			Frozen		
		Colour	Texture	Flavour	Colour	Texture	Flavour
Berkeley	1959	2·4	2·8	2·2	4·1	2·9	2·3
Bluecrop	1959	2·4	2·7	2·5	3·7	3·1	2·7
Burlington	1959	3·3	2·9	2·5	2·7	2·5	2·8
	1958	2·7	3·1	2·7	3·4	3·1	2·3
	1957	3·5	3·0	2·5	—	—	—
Coville	1959	2·9	2·8	2·4	—	—	—
Concord	1959	3·3	2·9	2·6	3·3	3·0	2·6
	1958	4·1	3·0	2·8	3·2	3·1	2·7
	1957	3·7	2·9	2·6	—	—	—
Jersey	1959	3·1	2·8	2·5	3·2	3·3	2·1
	1958	—	—	—	2·1	2·8	2·8
	1957	3·5	3·2	2·7	—	—	—
Johnston	1959	3·1	2·7	2·7	—	—	—
	1958	—	—	—	2·5	3·1	2·5
Pemberton	1959	3·6	3·1	3·2	3·7	3·0	2·7
	1958	3·0	2·8	2·7	3·0	3·1	2·3
	1957	3·1	2·7	2·6	—	—	—
Rancocas	1959	3·8	3·1	3·0	2·7	3·0	2·2
	1957	3·0	2·1	2·3	—	—	—
Rubel	1959	3·4	3·1	2·9	2·5	2·6	2·0
	1958	3·2	2·7	2·8	3·3	3·2	2·3
	1957	3·3	2·8	2·5	—	—	—
Stanley	1959	3·6	2·7	2·2	3·0	2·9	2·5
	1958	3·5	2·6	2·3	3·1	2·9	2·6
Mean	1959	**3·2**	**2·9**	**2·6**	**3·2**	**2·9**	**2·4**
	1958	**3·3**	**2·8**	**2·7**	**2·9**	**3·0**	**2·5**
	1957	**3·3**	**2·8**	**2·5**	—	—	—

TABLE III.

QUALITY OF FRESH BLUEBERRIES AND OF FROZEN FRUIT IN PIES : 1958.

Variety	Fresh Fruit			Pies (Frozen Fruit)		
	Colour	Texture	Flavour	Colour	Texture	Flavour
Burlington	3·8	3·3	2·2	3·7	3·0	2·9
Concord	4·1	3·6	2·6	4·1	3·2	3·0
Jersey	2·7	3·0	2·0	3·1	3·0	2·4
Johnston	3·2	3·2	2·0	3·3	3·1	2·8
Pemberton	4·0	3·4	3·1	3·4	3·2	2·7
Rubel	3·4	3·2	2·4	3·5	3·4	2·1
Stanley	4·1	3·4	2·7	3·7	3·0	2·4
Mean	**3·6**	**3·3**	**2·4**	**3·5**	**3·1**	**2·6**

It will be seen that the colour of the blueberries was well retained, particularly in the bottled fruit and the pies, and that the texture was satisfactory. The flavour was generally regarded as weak throughout, though there was considerable variation between the individual markings given; but those members of the tasting panel who had tasted blueberries in America did not differ significantly from the other tasters in their markings. In one series a small amount of lemon juice added to the fruit in the pies was considered an improvement, bringing the average rating for flavour in 6 varieties up to 3·1.

The varieties Burlington, Concord and Pemberton appear to be the most satisfactory of those varieties tested for three years; they have also been satisfactory in their growth (1).

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A REVIEW OF THE BRITISH BASKET-WILLOW-GROWING INDUSTRY.

By K. G. STOTT.

The willow-growing industry, which has been declining since the turn of the century, is suffering one of its periodic depressions, the severity of which has been noted in the House of Commons and in the national and local press. Reviews of the industry were made by Dawe and Blundell in 1932 (1) and by the Rural Industries Bureau and by Jarrett (2) during the last war ; in this article the present economic position is reviewed with particular regard to home production, foreign trade and competition.

History.

Basket-making and willow-growing are so intimately connected that it is impossible to discuss one without mentioning the other. Basket-making is a very ancient craft referred to in the writings of both Egyptians and Romans (3, 4). Originally baskets were made from wild willow but, as the trade thrived, a demand for uniform material was created which led in the 17th and 18th centuries to special commercial willow plantations in France, Germany and the Low Countries (5).

Britain imported willows from Holland until about 1800, when home production was stimulated by the Napoleonic blockade. The Royal Society of Arts then offered a prize to encourage home production, but it is unlikely that serious commercial production began earlier than 1820. In Somerset, which is now the main centre of production, this date coincided with the first large-scale drainage of the Somerset levels and their subsequent enclosure as a result of the Enclosures Act. Willow-growing provided an efficient and profitable use for wet river-valley land and quickly spread throughout the lowlands of England, especially in the Midlands and the South West ; it reached peak production in 1900, largely in response to an enormous demand for basket furniture.

20th Century. On the Continent, France had been the leading producer, but from 1900 Germany took the lead ; willow-growing spread also to Italy, Sicily, the Austro-Hungarian empire and Russia (5). During the first decade of the 20th century large scale importations of foreign baskets into Britain caused the decline of the British industry ; the Dutch Government subsidized the willow-growing industry in Holland and facilitated the cheap export of willows to Britain. This trend was halted by the 1914 war, during which the home industry enjoyed a period of prosperity, with prices reaching 27/- per bundle*. Many refugee basket makers worked in Britain during the war and became well acquainted with the demands of our basket trade. On their return home, Britain was again subjected to intense and frequently subsidized competition from the Continent, where wages were lower than those in this country.

Economic depression of the 1930*s.* From 1925 onwards Poland and Hungary competed in the British market on an ever-increasing scale. As a result of

*A bundle of processed *Salix triandra* measures 37″ in circumference, 2″ from the base. Approx. weight 26 lb.

foreign competition and economic depression the turnover of the home basket-making industry fell from £2,000,000 in 1925 to £1,400,000 in 1933. In 1932 the area devoted to willows in Britain stood at 3,000 acres (1), approximately half the acreage noted in *Agricultural Output of England and Wales for* 1925 (6). The greatest reductions in acreage occurred in the Midlands and East Anglia : willow-growing survived on a considerable scale only in Somerset. This was in many ways due to the efforts of the late Mr. H. P. Hutchinson, Willow Officer of the Research Station from 1922-39. He was instrumental in introducing in 1930 a mechanical willow-peeling machine which did much to keep willow-growers solvent in the depression of the 1930s. During this period the first authenticated economic report (1) on the Somerset willow-growing industry shows that there was little or no profit to be gained at the prices then current of 4/6d. per bundle.

The condition of the basket-making industry was little better, and in 1932 representation to the Government resulted in an import duty of 30% being levied on all basket merchandise imported into this country. This was imposed in 1933 but failed to bring about any material improvement in the basket industry despite the general improvement in trade. The tariff failed to benefit British manufacturers because foreign Governments raised the subsidies on baskets for export to counteract the British import duty.

The slump in home-made baskets led to local unemployment, and in 1936 the Board of Trade was approached to increase the tariff on imported baskets from 30% to 45%. This request was refused, and the basket-making and willow-growing industries had to struggle against foreign competition until 1939. The employment figures for the basket-making industry reflect this position :—

	Persons engaged in basket-making			
	1921	1931	1935	1940–45
Total	9,437	7,520	6,655	7,000
Unemployed ..	—	1,007	457	Nil

1939 *War*. With war imminent, there was in 1939 a considerable increase in Government contracts which brought all basket-makers into employment. The demand for basketry is always stimulated in war-time since timber must be used more profitably than for containers ; in addition, during the 1939–45 war willows were found uniquely suited to meet a new demand—the large-scale provision of airborne panniers.

All Continental supplies of willows were lost in 1940, and willows became in short supply. To the average annual home production of 2,000 tons were added annual imports of 3,000 tons from Argentina ; the fair distribution of supplies was co-ordinated by the National Basket and Willow Trades Advisory Committee. During the war 630 manufacturers employed approximately 7,000 basket makers, including those blind and disabled. The price of willows was controlled until 1944 at 22/6d. per bundle, and the willow-growing industry prospered. Like other fields of British agriculture it was stimulated by the war-time introduction of new methods and ideas.

Towards the end of the war it was suggested by representatives of the Trades Advisory Committee that considerable post-war expansion was possible

in both industries (7). It was prophesied that the trade could employ 25,000 basket-makers : a short-term programme aimed to increase the willow-growing acreage from 2,000 to 5,000 ; a long-term programme to 20,000, with an annual turnover in the willow-growing industry of not less than £2,000,000.

Post-war period. Though these measures were not even remotely achieved, the immediate post-war period saw the continuation of very large Government contracts which kept basket-makers working to capacity. The price of willows was decontrolled and rose steadily. Home producers benefited from social and political upheavals in Argentina which priced Argentine willows out of the British market, and though imports from the Continent increased, they could not keep pace with the increase in demand : by 1957 willows were again in critically short supply.

The scarcity of Continental willows was due not only to the wartime devastation of Continental willow beds but also to the fact that Western Germany, through partition, had lost most of the willows in Silesia. Western Germany now absorbed large quantities of Belgian and Spanish willows that might otherwise have reached Britain, where Polish willows were also unavailable in quantity.

With willows in such short supply, the price rose in 1957 to 37/6d. per bundle, and many small basket-makers found they could not obtain economic supplies, and left the trade for other occupations. Serious labour shortages occurred in both the basket-making and the willow-growing industries.

Present depression. The beginning of the present depression can be traced to the summer of 1957. During that season many of the large Government contracts ceased, and some Blind Institutions met their dwindling orders from stock, and bought no willows. The general trade recession that occurred in 1958 had a profound effect on the basket-making industry since most trades use baskets for transport or packaging ; few demands were made for new baskets by such large industries as the Lancashire and Yorkshire textile trades. Hence, during the period 1957–58 the demand for baskets was light, and many more basket-makers left the trade.

At this time there was a marked change in willow imports. Areas of newly planted basket-willows came into bearing in Western Germany, with the result that Belgian and Spanish growers turned to Britain for a market. Well-graded Spanish willows were imported at prices about half those of British willows. Thus, on a falling market, supplies of willows again became plentiful. The change was marked by a dramatic fall in prices for standing willows at the November willow auctions in Somerset : the price in 1957 was a half, and in 1959 one-third that paid in 1956. There was a similar fall in the average price of bundles—from 37/6d. to 20/– : even willow of reputable quality sold for 25/–.

With trade recovery in 1959 there has again been a plentiful demand for baskets, but because many basket-makers had left the trade during the previous two years, orders have had to wait for lack of skilled employees. The demand for willows is therefore less than it would have been if the number of basket-makers had not fallen. There has been a tendency to blame imports entirely for the serious fall in home prices. This is not justified : the volume of imports is only about 15 per cent of home production. In fact, imports in 1959 had fallen to the lower level current in the period 1952–56.

Though there is at present a vogue both in domestic baskets and in

basket furniture, home basket-makers have had little participation in this trade. The imports of basket-ware have increased forty-fold from 1946 to 1959 and there has been a recurrence of the situation that obtained in the 1930's : demand has been met predominantly by articles of cheap foreign manufacture ordered and sold in bulk, particularly by the chain stores.

Acreage and Production of Willows.

It will be seen from Table I, which gives the European acreage of basket willows, that the acreage of willows in Britain is small compared with that in Holland and Poland.

TABLE I.

EUROPEAN ACREAGE OF BASKET WILLOWS.

Holland	13,838	1956
Poland	10,500	1959
Britain	1,784	1959
Spain	1,500	1958
Western Germany ..	7,500	1959

Figures of British acreage can be regarded only as estimates because willows are unfortunately not included in the crops declared for the July return of the Ministry of Agriculture ; nor are basket willows included in the census of woodlands conducted by the Forestry Commission. In 1925, *Agricultural Output of England and Wales* (6) gave a national total of 6,000 acres, to which Somerset and the seven counties listed in Table II contributed 50%. More detailed information can be found in Ministry of Agriculture Bulletin No. 89, *Osiers and Willows* (8) ; it gives the total acreage for 1933–4

TABLE II.

BRITISH ACREAGE OF BASKET WILLOWS.

	1925 (6)	1933–4 (8)	1953	1957	1959
Somerset	*	1570	1355	1327	1206
Dorset	*	—	2	1	3
Gloucestershire ..	*	100	6	6	7
Worcestershire ..		50	5	0	0
Berkshire	*	170	55	15	15
Cambridgeshire ..		66	110	114	114
Huntingdonshire ..		107	26	26	11
Essex		38	0	4	2
Norfolk		43	42	45	40
Suffolk	*	303	221	215	131
Staffordshire ..	*	275	43	38	26
Nottinghamshire ..	*		30	31	32
Lancashire	*	176	49	39	35
Other counties ..		—	327	257	161
Total	6000	2898	2271	2118	1784

* 50% of total in these counties collectively.

as 2,898, distributed as in Table II. A survey by Long Ashton of all basket-willow-growers and basket-makers known to the National Agricultural Advisory Service and the Rural Industries Bureau and Rural Community Councils

between 1949 and 1959 showed a total of 2,271 acres in 1953 ; 2,118 in 1957 and 1,784 in 1959. Thus the total acreage was halved between 1925 and 1934 and was not materially increased during the period of war and post-war prosperity ; it decreased yet further in the period 1958–59.

Somerset.

From the outset of willow-growing in Britain, Somerset has always been an important area ; it alone has resisted foreign competition and it is now the only extensive area of willow-growing in the country. The acreage devoted to willows in the levels of mid-Somerset is more accurately known (Table III). In 1932 the total area was recorded as 1,570 acres during an economic survey of the Somerset willow-growing industry based on the 25″/mile Ordnance Survey maps (1). A field-by-field check in 1936–8 by the Land Utilization Survey (9) gave 1,740 acres. In 1940 an assessment conducted for the Ministry of Agriculture (2) gave the Somerset area as 1,354 acres, which was probably accurate. In 1955 a detailed field survey conducted from Long Ashton showed an area of 1,310 acres (Table III). This figure increased to 1,357 in 1957 and then, because of the economic conditions then prevailing, dropped rapidly to 1,206 in 1959.

TABLE III.

SOMERSET ACREAGE OF BASKET WILLOWS.

	1932 (1)	1938 (9)	1940 (2)	1955	1956	1957	1958	1959
Total	1570	1740	1355	1310	1327	1357	1325	1206
Planted					39	30	25	14
Grubbed out ..					22	0	57	133

Volume production of S. triandra *Black Maul.* Though the fall in acreage appears great, it is partly offset by changes in the age of beds and in the varieties grown. In the post-war period high prices made it worth-while to retain old beds of low productivity, but since 1958 most of these have been grubbed or destroyed. Of the 133 acres of grubbed willows noted in Table III, 70% were 20–40 years old and the rest were 10–20 years old. Thus volume

TABLE IV.

AGE CLASS DISTRIBUTION : SOMERSET BASKET WILLOWS.

1932 Assessment (1)				1958 Assessment			
Planting Date	Age (years)	Acres	%	Planting Date	Age (years)	Acres	%
1932–27	<5	58	9	1958–53	<5	396	30
1927–22	5–10	83	13	1953–48	5–10	174	13
1922–17	10–15	119	18	1948–39	10–20	333	25
1917–12	15–20	108	17				
1932–12	0–20	368	**57**	**1958–39**	0–20	903	**68**
1912–07	20–25	248	39				
1907–02	25–30	28	4				
1912–02	20–30	276	**43**	**1938–18**	20–40	384	**29**
Total for sample		644		**Pre 1918**	>40	39	**3**
Total acreage		1570	100			1326	100

TABLE V.

VARIETY AND AGE CLASS DISTRIBUTION : SOMERSET BASKET WILLOWS.
(Acres)

Planting Date	Age	*Salix triandra*						*Salix viminalis*	*Salix purpurea*	Other varieties and mixtures	Total
		Black Maul	Champion Rod	Whissender	Newkind	Black Spaniard	Old French				
1958–53	Under 5	326	23	6	37	4	0	0	0	0	396
1953–48	10–5	89	42	29	6	8	0	0	0	0	174
1948–38	20–10	276	32	10	3	9	0	4	0	0	333
1938–18	40–20	269	58	3	2	45	0	7	0	0	384
Pre 1918 ..	Over 40	24	12	1	1	1	0	0	0	0	39
Total		894	167	49	49	67	0	11	0	0	1326
Per cent. of total		74	12	4	4	5	0	1	0	0	100
Total 1932* ..		1039	190	0	18	170	36	52	28	37	1570
Per cent. of total		66	12	0	1	11	2	4	2	2	100

* Estimated from a sample of 880 acres (1)

production has probably fallen little, because the acreage removed has consisted mostly of old beds. Beds give their maximum yield between 7 and 15 years old ; Table IV shows that 30% of the present acreage was less than 5 years old in 1958 and 43% was under 10 years old. A reasonable proportion of the beds are therefore young and vigorous, whereas in 1932 considerations based on an economic rotation of 20 years showed that the acreage of beds under 10 years old was only one-third the normal, while that over 15 years was twice the normal (1).

Black Maul is the willow in greatest demand by the basket-makers ; other varieties have special uses and many are of limited value. It will be seen from Table V that the acreage now devoted to these varieties, (columns 7–11) is only 6% compared with 21% in 1932, whilst the proportion under Black Maul has risen from 66% in 1932 to 74% in 1958. The acreage under this variety has dropped only from 1,039 acres in 1932 to 894 acres in 1958 and since a greater proportion of the beds are young it is likely that the volume of Black Maul now being produced is little lower than in 1932, when the total acreage under willows in Somerset was 1,570.

Prices.

Table VI gives the average price per bundle of Somerset willows, buff and white. The outstanding price is that of 27/– reached in 1918, when large profits were made. The cost of production could then have been little more than in 1932, when it was calculated as about 4/– a bundle (1). The prices obtained in 1956 and 1957 reflect the scarcity of willows at that time. In the winter of 1959–60 agreement between the Basket-makers' and Willow-growers' Associations led to the adoption of 26/– per bundle buff and 28/– per bundle white.

TABLE VI.

PRICES PER BUNDLE OF PROCESSED WILLOWS.
(Shillings)

	1918	1932	1941–44	1953	1954	1955	1956	1957	1958	1959
Buff	27	4·5	22·5	25	25	26	28	32	28	26
White				27	27	30	30	34	30	28

TABLE VII.

PRICES OF STANDING WILLOWS : SOMERSET PUBLIC AUCTIONS.

	1953	1954	1955	1956	1957	1958	1959
Total acreage auctioned ..	127	141·1	144·5	144·1	170·4	202·8	125·8
Total acreage withdrawn ..	2·4	1·3	5·2	6·3	31·8	84·4	42·0
Per cent. withdrawn ..	1·9	0·9	3·6	4·3	18·7	41·6	33·4
Total acreage sold	124·6	139·8	139·3	137·8	138·6	118·4	83·8
Total value (£) of willows sold ..	10,074	13,093	13,674	12,505	9,248	5,124	2,818
Average price (£) per acre sold ..	80·9	93·6	98·2	90·7	66·7	43·2	33·6

Table VII gives the mean prices obtained at the two willow auctions held in Somerset every autumn. The willows are sold standing : the purchaser has to pay 25% of the purchase price as a deposit, and has eight months in which to pay off the remainder ; he cuts the willows and markets the produce.

The acreage auctioned remained constant from 1953 to 1956 and the price rose to £98·2 per acre ; this represents a substantial profit for the grower. In the autumn of 1957, coincident with the cessation of many Government contracts for basketware, the price per acre dropped to £66·7 and in 1958 to £43·2. At the same time growers had difficulty in finding private purchasers for their beds and the acreage put up for auction increased ; buyers were prepared to buy only the better quality crops and so the percentage unsold or withdrawn increased noticeably. The turnover was only £2,818 in 1959 compared with £13,674 in 1955.

Imports.

Basket willows worth £54,261 were imported in 1920 (10), but Table VIII shows that only half this value was imported in the period 1927–1933. During the last war 3,000 tons of Argentine willows were imported annually at an estimated value of £225,000 ; but from £134,172 in 1946 the value of total imports fell to only £18,086 in 1952, rising to £51,482 in 1957 and then falling to £30,833 in 1959. The low value of imports in 1952 is outstanding ; allowing for changes in the value of money it represents the lowest volume of imports for at least 40 years.

The noticeable features of Table IX, which gives the source of imports, are the replacement of Argentina by Madeira, and the sudden importation of Spanish willows in 1957, which caused an increase of 25% in the value of imports in that year. It should be noted that from 1957 willows have been incorporated by the Board of Trade in the designation " Canes and Rattans not elsewhere specified, sticks unmounted and willows for basket-making." Fortunately, since willows are a temperate crop and canes and rattans tropical, it is possible to differentiate between the countries of origin listed, to derive the estimates of willow imports given in Tables VIII and IX.

Table VIII gives the value of imports of baskets and total basket-ware. Under baskets are given the figures designated by the Board of Trade as " Baskets manufactured wholly or partly of willow, cane, or wicker." Total basketware sums these figures and those designated by the Board of Trade as " Other descriptions including furniture and fitted baskets."

There was a steady decline in imported basketware from £557,351 in 1920 to £167,000 in 1938, similarly a decline in baskets from £16,086 in 1927 to £4,740 in 1933. Basket imports rose tenfold from £20,529 in 1946 to £285,665 in 1958 ; those of total basketware rose twentyfold, but despite this tremendous postwar increase, the value is only equivalent to that of 1938 if the latter is revalued at present prices. Thus the volume of imports in 1958 was probably similar to that in 1938, and represented only half of the quota fixed by international trade agreements for foreign imports (11).

In 1959, imports increased by 50% to the very high value of £801,396 It is very difficult to assess the effect of these imports on home production : it has been suggested that only items designated as " Baskets manufactured wholly or partly of willow, cane or wicker," concern the home trade and that

TABLE VIII.

IMPORTS OF WILLOWS AND BASKETWARE.

(£)

	1920	1927	1930	1933	1938	1940–43	1946	1947	1948	1949
Willows	54,261	19,835	29,571	15,181	13,762	225,000	136,172	174,062	119,306	71,781
Baskets		16,086	15,070	4,740			20,529	68,930	84,136	74,851
Total basketware	557,351	419,071	419,240	208,957	167,000	Nil	20,931	72,805	87,595	93,513

	1950	1951	1952	1953	1954	1955	1956	1957*	1958	1959
Willows	59,294	60,647	18,086	26,583	30,529	32,624	36,155	51,640	40,552	30,833
Baskets	67,709	92,245	80,817	97,646	120,023	118,962	142,013	219,513	285,665	
Total basketware	184,757	342,711	272,690	287,053	271,100	278,743	334,705	478,262	549,101	801,396

* From 1957 onwards the values of willow imports are estimated.

TABLE IX

SOURCES OF WILLOW IMPORTS.

(£)

	1950	1951	1952	1953	1954	1955	1956	1957†	1958	1959
Commonwealth and Eire ..	11	3	257	96	—	—	124	158	—	13
Netherlands	8,790	9,587	3,194	13,491	12,902	13,962	14,255	12,742	8,701	6,202
Madeira	2,236	1,290	4,120	8,469	2,760	12,774	14,956	17,982	13,032	11,384
Argentina	34,098	40,262	4,052	—	9,906	—	—	—	—	1,440
Poland	9,820	4,164	3,436	} 4,527	} 4,961	} 5,888	2,210	665	1,615	2,145
Belgium	1,609	4,583	3,027				3,976	1,939	2,474	1,218
Portugal	592	458	—				634	—	—	486
Spain	—	—	—	—	—	—	—	15,493	9,241	2,919
West Germany	—	—	—	—	—	—	—	2,098	3,907	1,399
France	1,295	—	—	—	—	—	—	563	1,508	587
Other foreign countries ..	843	300	—	—	—	—	—	—	74	3,040
Total	59,294	60,647	18,086	26,583	30,529	32,624	36,155	51,640	40,552	30,833

† From 1957 onwards values of willow imports are estimated.

in 1958, of £285,665 listed under this heading and included in the total of £549,101, only £130,000 represented direct competition with the ordinary basket trade (11).

Discussion.

The British basket industry reached peak production about 1900 : it declined because basketry ceased to be fashionable. In industry, and particularly in the fruit trade, it was replaced by more convenient forms of packaging such as non-returnable containers, and it suffered from imports of foreign basketware, often at subsidized prices.

In the 1930s there was little recruitment. Of the 7,000 workers employed during the war, many had been recalled from retirement as a special measure. There was therefore a very sudden fall in the number of active workers at the end of the war. From 1955 to 1957 the shortage and high price of willows made it difficult to compete with increasing imports, and basket makers turned to more lucrative employment. In 1957 many Government contracts were withdrawn which, coupled with the general recession in trade, encouraged more to leave the industry. The decline was also due to the fragmentary nature of the industry and to the innate conservatism of its employees, for though imports competed mainly by price, a more enterprising industry would have taken greater advantage of the increasing popularity of basketware ; in 1959 this was met by imports valued at £801,396, of which at least £200,000 could have been home produced.

With the recovery of trade in 1959 and the vogue in basketry, those basket makers remaining are now working to capacity. It is, however, unlikely that numbers in the industry will greatly increase ; basketry does not lend itself to mass production methods, the apprenticeship is long and though the craft is interesting and satisfying it will tend to become localized in centres such as Blind Institutes and prison workshops.

In the present century the British willow-growing industry has prospered only between 1914 and 1918 and between 1939 and 1957. From 1946, as Government contracts declined, imports fell, being particularly low from 1952 to 1957 : the demand for home willows was steady, and good prices were obtained ; even old beds were economic and a certain amount of replanting was undertaken.

In 1957 the decline in the demand for British baskets and willows coincided with a 25% increase in willow imports and an increase in the imports of other competitive raw materials, so that prices paid for standing willows at the public auctions, and for finished bundles, fell dramatically. At these prices it was no longer economic to retain old beds ; the majority were grubbed and the acreage in Somerset fell to 1200. However, since a good proportion of the beds are young and productive, and only a small acreage is now devoted to poor varieties, the drop in production of the main variety, Black Maul, will not be great, and the supply should match current demand.

Growers are at last taking advantage of new materials and methods to produce better crops at more competitive prices. The fall in imports since 1957, particularly from Spain, has been due not only to lower home prices but also to the realization that the quality of home willows, if adequately graded, is equal to or better than that of Continental willows. Other things

being equal they have, in fact, always been given preference by the British basket maker although the quality of Argentine willow has always been admired. Only 10% of the present willow imports are necessary to fulfil special requirements. There is no reason why willows worth £30,000 should have been imported in 1959 when British growers had unsold stocks of the same value.

Since 1957, imports have fallen to a value at which the demand for home willows should remain steady. Willow growers are now competently organized as a specialist branch of the National Farmers Union. A scheme has been introduced to encourage the production of well-graded standardized bundles, at prices negotiated with the basket makers so that supply and demand can be co-ordinated to achieve a period of stability, and enable both these small but relatively important industries to meet foreign competition.

Summary.

The history of the British basket-willow-growing industry is reviewed in relation to the economic depression of 1958 and 1959.

The areas devoted to willows in Britain are described and the main area, Somerset, is considered in detail. Changes in acreage, recent plantings and grubbings are recorded and the age class distribution of the main varieties is given. The growing importance of the variety *Salix triandra* Black Maul is shown.

Information on prices and demand at the Somerset auctions is presented as evidence of the present economic depression. The main causes of the depression are discussed, including the effect of imports of willows and basket ware.

Recent improvements in the organization of the willow-growing industry are described.

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Month	Air Temperature (°F.)							Rainfall (″)			Sunshine (hours)		Soil Temperature at 09·00 G.M.T.		
	Means		Means of A & B	Diff. from normal	Max.	Min.	No. of ground frosts	Total	Per cent. of average	Most in a day	Daily mean	Per cent. of average	4″	8″	24″
	A Max.	B Min.													
January	43·2	32·6	37·6	−2·8	54	20	22	3·94	118	0·84	2·53	169	36·2	37·4	40·9
February	45·3	35·6	40·1	−0·6	61	27	13	0·33	13	0·27	2·13	81	37·6	38·4	39·9
March	52·3	39·7	46·0	+2·1	60	31	14	2·74	120	0·41	3·55	92	43·3	43·8	45·2
April	56·4	43·1	49·8	+2·2	68	35	7	2·87	131	0·60	4·91	90	48·9	48·5	49·3
May	65·2	45·9	55·5	+2·4	74	33	6	1·68	65	0·37	7·02	112	56·5	55·7	54·9
June	67·5	51·2	59·4	+0·9	76	40	0	1·74	79	0·50	6·95	100	62·9	62·1	61·0
July	72·0	54·2	63·1	+1·6	84	47	0	3·05	97	0·89	7·32	115	66·2	65·1	63·4
August	71·7	54·8	63·3	+2·3	82	42	0	1·36	37	0·54	6·38	107	65·0	65·1	64·3
September	71·1	49·3	60·2	+3·1	81	37	2	0·19	6	0·16	7·08	151	59·9	60·9	62·1
October	63·4	47·1	55·3	+4·2	79	35	2	3·57	96	1·31	4·67	143	52·9	54·2	57·4
November	52·1	40·3	46·2	+1·4	61	27	11	4·38	119	1·03	2·02	107	44·6	45·6	49·1
December	49·5	39·0	44·3	+2·9	55	28	12	7·00	191	0·71	1·28	87	41·8	42·9	45·6
Totals or Means ..	59·2	44·4	51·7	+1·6			89	32·85	91		4·67	112	51·3	51·6	52·8

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THE JOURNAL OF HORTICULTURAL SCIENCE

The Journal of Horticultural Science, which is sponsored by the Long Ashton Research Station and the East Malling Research Station, welcomes contributions on horticultural science from Research Institutes at home and abroad. Papers for publication and all communications should be sent to the Editors at East Malling Research Station, Maidstone, Kent.

Papers already accepted for publication in the current Volume 35 (1960) have been received from both the sponsor Stations, from the National Vegetable Research Station, the Glasshouse Crops Research Institute, the Scottish Horticultural Research Institute, Nottingham, Reading and London Universities and the National Agricultural Advisory Service in the United Kingdom, and from Canada, Trinidad, India and Ghana. Many reports deal with various aspects of apple culture ; raspberries, hops, bananas, custard apples, cocoa and tomatoes are among other fruit crops discussed. A study of yearly variation in vegetable crops is described and aspects of summer cauliflower and radish culture are also dealt with. There is a paper on the effects of environment on chrysanthemum. A wide range of subjects includes plant nutrition, growth studies, dormancy, breeding, planting density, weed control, storage, top grafting and disease control.

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